

A  
TREATISE  
OF ARTIFICIAL  
FIRE-VVORKS

Both for VVarres and Re-  
creation : with divers plea-  
sant Geometricall observa-  
tions, Fortifications, and  
Arithmetical Ex-  
amples.

In fauour of Mathematicall  
*Students.*

Newly written in FRENCH, and  
Englised by the Authour  
FRANCIS MALTHVS.



Printed for RICHARD HAVV-KINS, and are  
to be sold at his Shop in Chancerie-lane neere  
to Sericants Inne. 1629.



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A TREATISE OF ARTIFICIAL  
ALL FIREWORKS &c. by R. H. H. H.



LONDON  
for Richard H. H. H. in Chancery  
Lane. 1629







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# TREATISE OF ARTIFICIAL FIREWORKS

Both for Voyages and Re-

creation: with divers pla-

ces Geometrical, Optical,

Acousticall, and



In Honour

Newly written in French, and

Englished by the Author

THO: MATTHEW.



Printed for RICHARD HAVKINS, and

to be sold at his shop in St. Dunstons Church Lane near

St. Dunstons Church 1699.



# THE PREFACE

Apologetique to the  
Reader.



Although that Warres haue  
beene authorized by the  
diuine powers, as witnes-  
seth the new and old Testa-  
ment, yet me thinkes I heare many nice,  
peeuish, and ignorant braines blaming me  
for setting downe to the view of the  
world (at a few leisurely houres) so many  
wayes and inuentions how to corrupt and  
destroy what nature and art stroue to  
make, edifie and conserue, to whom I an-  
swer they haue the same reason to exclaim  
against iustice which hath found and or-



## The Preface.

dained many meanes to abolish and exterminate wicked offenders: for my intention is here but onely to finde inventions to confound and ruinate Rebels and their habitations; that afterward Empires, Kingdomes, and Commonwealths may the better liue in peace and tranquillitie: and what more is I haue set downe perspicuously this Treatise of Fire-workes, which many heretofore haue written with confusion and great danger, having pend large Volumes with most ample and idle discourses touching this subiect, whose names for modesties sake I will not here set downe with an infamous character to posteritie (as Master Robert Norton hath done some few slight offenders names in the Preface to his translation of Vitanos works, which he calleth his owne, hauing onely added seven figures taken out of Thybourels booke,



## The Preface.

booke, and transposing the Authours  
workes to disguise it) that I bee not ac-  
counted amongst the calumniators of this  
age, who write with serpents tongues spit-  
ting their venome vpon the silent and  
sleeping innocents gone before vs. But  
I will onely shew their errors in generall,  
that the learners may the better auoyde  
them: For in some you shall see prescri-  
bed all sorts of Apothecaries drugges  
for the compounding of Fire workes,  
which are no more capable of fire then  
stones, earth; or mettle, as Adamant-  
stone, Verdigrease, Cristall, Vitrioll,  
Salarmoniacke, Sublime, Mercurie, with  
a number of the like, which in the iudge-  
ment of ignorants may produce in Fire-  
workes wonderfull effects. In others  
you shall finde the coniunctions of com-  
bustible materials in such a sort or man-  
ner

## The Preface.

ner disposed and ordered to such  
strange ends, that you would say they  
were set downe to make the Reader  
laugh, rather then for seruice of Fire-  
workes eyther for Warres or Recreation,  
as the meanes how to poyson an  
Armie in the wide Field by the smoake  
of an artificiall Ball, is it not to be  
thought a very prettie imagination, or  
else that the Ball ought to bee some-  
what bigge; and afterward which is  
more ridiculous, you shall finde in the  
same Authours the same ingredients  
and mixtures prescribed for Fireworks  
for Pleasure and Recreation: which  
to mee seemes strange, that the Fire-  
workes whose smoakes are so venemous  
even as to poyson Armies in the open  
Fields, shall bee also fit to burne in  
the middle of a Cittie or Towne a-  
mongst

## The Preface.

mongst thousands of people for Re-  
creations: now all these idle conceits  
with a number of the like are printed  
in many new and recent bookes; the  
Authours whereof doubtlesse haue set  
downe all these ridiculous in-ventions  
by ignorance, (thinking them good)  
and not of purpose for spight; and  
therefore they doe deserue pittie rather  
then blame; as well as Master R O-  
BERT NORTON, (who hath er-  
red onely in attributing another mans  
workes, and faults to bee his owne)  
and what is it that giues mee cause to  
thinke that all these haue erred by ig-  
norance, is because that all their  
workes are alike where that they doe  
speake of Fire-workes. But reading  
these absurdities with a great quantitie  
of others, which made mee take reso-  
lution



## The Preface.

lucion to set my penne to paper, and  
shew to posteritie how and what way to  
auoyde their errours, having beere set  
downe the true rules and mixtures re-  
quired for Fire-workes, both for  
Warres and Recreation, with some  
few Geometricall obseruations necessa-  
rie for the practise of Fireworkes in  
warres; and also I haue added vnto it  
certaine rules and maximes of Fortifi-  
cations, very requisite for Enginiers to  
haue in their memorie, with a compendi-  
ous Arithmetike, hauing written the  
whole first in French at some broken  
houres whilest I followed the warres, and  
bringing certaine coppies from the Presse  
to my Speciall and very good friends;  
at whose requests I haue translated the  
same into English, that others might  
not translating it, mistake my meaning;  
no. 111 and

## The Preface.

and the worke being already but of small  
commendations, they to make it of les-  
ser. Adieu. London the 22. of May.  
1629.

The

The Preface

and the work being already put off  
considerations, they to make it of less  
for Advice London the 22. of May.

1629.

The





To the Authour.

**T**Hy Archimedean hand hath learnt to frame  
Celestiall Meteors out of *Nitrous* flame:  
And represents strange fires of differēt sorts  
Suted to Martiall vse, & Courtly sports: (houres  
So pleasing that great Kings haue spar'd some  
To be spectators of thy golden showres.

The Thames and Seyne haue seen thy Balons fly,  
From their affrighted bosomes to the skye:  
Swift beyond all beliefe; as if thy ayme  
Were, to restore *Promethæus* theft againe. (sunder  
Where, when their force seems spent, breaking a-  
They rain down stars, or els outroar the thunder.

The Roman Apotheosis I deeme,  
Would still haue had a reuerent esteeme,  
If they had vs'd these miracles of fire,  
To mount their *Cæsars* soules, & beare the higher  
Then Eagles flight, but now they serue to raise,  
The Pyramis and Trophe of thy praise.

And

## To the Authour.

And sure thou hast attain'd sufficient glory,  
In perfecting the Pyrotechnique story:  
Which some tooke vp on trust, & by concealing  
Their creditors; made borrowing to seem stealing.  
But their fire's out, now thine hath pass'd the  
For greater fires do extinguish lesse. (Presse.

Thy Archimedes hand hath learnt to frame  
Celestiall Meteors out of Vapour flames:  
And represents strange fires of distant sort  
Suted to Mariall vte, & Courtly sport: (houses  
So pleasing that great Kings haue par'd some  
To be spectators of thy golden shewes.

**WILLIAM BASTIAN** *studious*  
in *Mathematicks*.  
From their axis all the skyes  
Swift beyond all belife; as if thy ayne  
Were to restore Pomeroyes their againe. (under  
Were, when their force seems spent, breaking as  
They rain down stars, or els out of the thunder.

The Roman Apotheosis I deeme,  
Would still haue had a reuerent esteem.  
If they had vs'd their miracles of fire,  
To mount their Cyparissus, & beate the highest  
Then Eagles flight; but now they seeme to raile,  
The Pyramids and Irophe of thy praise.

And



# A TREATISE OF FIREWORKES.

for Warre.

## CHAP. I.

**T**O imitate nature, our first and chiefeſt teacher, who far from error ſeemes to haue produced and brought forth all things by a curious and ſpeciall order; without whole beautifull diſpoſition the whole world had ſtill continued in the moſt prodigious confuſion of *Caos*, which diſpleaſed the preſpect of the higheſt, eternall

P. B. 36.

and

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and divine powers, being but a cloud or mixture of darknesse. My intention is here to institute and obserue an order, treating of euery thing one after another in his proper and conuenient place: beginning with artificiall Fire-workes, as the chiefeft and principall cause which hath vrged me to take my penne in hand, the description of those which belong to warres, shall obtaine the first place, and next the Fire-workes for recreation or pleasure, passing from these to many pleasing Geometricall obseruations, aswell of Mecanical obseruation, as by the sines, tangents, & succents, ioyning to them a most easie & succent method to fortifie all places regularly and irregularly. And to conclude I will adde many  
briefe

briefe and instructiue Arithmeti-  
call examples.

Now to begin with the Fire-  
workes for warres, I will first de-  
scribe the Morter-peece, and the  
vse thereof: that being an instru-  
ment, the most noble, the most v-  
niuersal, the best of greatest effect,  
and of most wonderfull operation  
of all the instruments, the practise  
wherof may be vfed amongst Fire-  
workes for warres, for this instru-  
ment may serue for a Petard to  
split, breake and hurle down dores,  
gates or walles, likewise to massa-  
cre, teare in pieces, ouerthrow and  
confound assailants of any place  
or breach: and for diuers other  
most worthy offices, and acciden-  
tall occasions, which happen in the  
troubles of warres: whereof I will

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not here make a long, weary, and tedious discourse, but in few words cleerly set downe the vse of this instrument for the shooting of diuers sorts of granads, stones, or other weighty burthens to ruine rebels, their habitations and dwelling places. Then first of all I will treat of the mettle, whereof this instrument ought to be made, and measures appertaining thereunto.

CHAP.



## CHAP. II.

### *The manner how to make the Morter-Peece.*



His Instrument may bee made of diuers sorts of mettles or stufte, according to the means, times and occasions which shall offer themselves to those who would make them, or cause them to bee made. The first and chiefeft matter of all, is red copper, brasse and tinne, but very little of the two last, such as Canons are made of, without any other bricke or harsh mettles mingled with it, and beeing

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made of this stuffe, let the measures following be observed. If the diameter of the calliber or bore be one foot, let the mortar be two foot of length, & let the sack or hole for the powder be the third part of a foot broad, and halfe a foot deep, and let the mortar beare in thicknes an inch and a halfe, about one foote high, and the rest onely one inch thicke, the foot shall bee one inch and a halfe thicke, and made square whether the instrument be for the seruice of warres, or recreation, as doth plainly demonstrate the Figure A following. The second mettelle is yron, such as commonly Ordnance for ships are made of: and being cast of this stuffe, the rules prescribed shall be found fit, onely let the mettelle be somewhat thicker

thicker in euery place. The third and fourth, and most common materialls are past-boards and canvas, or pastboords and chord, and



either of these materialls must be ioynd together with glue, and being to be made of either of these materialls there must be had a wo-



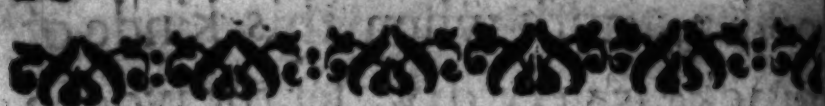
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den foot, with the powder sacke or hole made hollow below in the wood, as is represented by the Figure B. the precedent measures being obserued which is the third part of the diametre, &c.

But if the instrument be to bee made of either of the two first mettalls, that belongs to the Founders office, but of the two last materials euery man at his owne pleasure may compose it of what size he please, and to begin he must haue a wodden rowler of such bignesse as he shall desire to make the diametre of his Morter-peece, and vpon that rowler let the pastbords and canuas with good store of glue be rowled: which being done let them dry a while vpon the rowler, and another while off from the rowler,

rowler, and when this kinde of  
 truncke is very dry, let the woden  
 foot be ioyned to the one end with  
 glue and nailes very fast; and then  
 couer the whole with chord and  
 glue againe; which being well  
 dryed, the instrument may bee of  
 long service, provided that it bee  
 not over-charged, and as for the  
 length, the longest carry furthest,  
 and the thickest dure longest, by  
 the figure C. precedent the instru-  
 ment is represented perfect, with  
 the touch-hole in the right place  
 required.

CHAP.



## CHAP. III.

*The manner how to make granades  
or mettles for the mortar, or hand.*



LI granads being made  
to breake, ought to  
be composed of the  
most bricke mettles  
that may be found, as of brasce,  
adding the third part of Tin to it.  
(as the Founders know right well)  
they may be also made of yron, or  
of glasse to cast out of mens hands,  
so that the glasse bee made very  
thicke, and these will worke won-  
drous effects, especially in any  
throng of horsemen or footmen.  
And as for the thicknesse of those  
which are made of brasce, if the di-  
ameter



for Warre.

II

meter be one foot, let the mettles be one inch thicke, and let them be somewhat longer then they are round: as doth demonstrate the figure A. leauing at the one end, as it were a handle, and on the other, a screwed hole, by which meanes the granad may be charged, also, let there be made a hollow vice fitting for the former screw, which vice shall be filled with a slow composition made with gunpowder well bruised and culled, and then made into past with oile of petrole: but if the powder be excellent good and strong, then mingle with a pound of powder, one ounce of Charcoale dust, to make it weaker, then let the composition bee yvell beaten into the hollov vice, ywhich is represented by the figure B.

And

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And the granad shal be filled with  
fine gun-powder, which being full,  
let the vice be screwed into the  
hollow hole of the granade, onely



it is to be noted that the vice must  
not be open at the lower end, but  
have a bottom fodered strongly,  
wherein shall bee made three or  
four

four little holes about the bignes  
of a tag of a point to giue fire to  
the powder when the granad hath  
flowne the space required. For  
the performance wherof it is need-  
full that you know the quicknesse  
or slownesse of the mixture wher-  
with the hollow screw is to be fil-  
led. And for the better experience,  
it shall bee conuenient to make  
triall of one with a granade made  
of wood, eloath, pastboord, or a-  
ny other stuffe filled with earth,  
but let it be neere to the weight of  
those which you desire to make  
use of, afterward, and by that  
meanes you may know how long  
you ought to make your hollow  
vices, which are called by their  
proper tearmes Port-fires, and  
thus much of your granade being  
per-



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performed, now let it bee all covered over, vvith either Chord, Canuas, or Pastbeord, and dipped in glue or in pitch; this covering may be neere halfe an inch thicke: to the end that the granade going out of the Morter vvith violence it breake not, and vvorke his execution vpon your selfe or your company instead of your enemies; of vvhat mettall soever the granad is made, these rules are to be observed, and by the figure C, is represented a granade quite finished; and dipped into pitch, by vvich meanes it may bee conserved many yeares: these sorts of granads vvorke great effects falling vpon houses; they cast downe the vualles and coverings, likewise

wise they vvorke vvonderous o-  
perations amongst either horle-  
men or footmen, tearing both  
man and beaft in pieces, sparing  
nothing.

**CHAP.**



# CHAP. IV.

## *The manner how to make Granads of Canuas for the Morter.*



He operation or execution of these sorts of granads made of Canuas is quite contrary to those prescribed: these are onely fit to set a Towne on fire, the houses whereof are most couered with reede, straw, or broome, they are not of so violent execution as the precedent, yet notwithstanding of as great cost, and for the making of them, you must haue a wooden rowler



rowler, which is represented by the figure A, of the bignesse you desire to make the granad (which alwaies ought to be lesse then the Calliber or bore of your mortar, to the end they may bee covered afterward) and vpon the rowler make a sacke of such cloth as you please, as doth represent the figure B, cutting a piece to couer the vpper end, when the sacke shall be full of the composition following. Take foure pound of salt-peter, two pound of gunpowder-dust, two pound of brimstone, all these being well pulverised, let them be moyltened with oyle of petrole, and then fill your sackes with the same, and cover them with chord, which done, pierce the sacke full of holes with a grea bodkin, as representeth the figure E, and in euery

C

hole,

hole, place a little yron batrell charged like a pistoll barrell, these little barrells are represented by D, which must be driven into the sacke vp to



the head, and the granad being thus disposed, let there be made at the one end a hole about one inch deepe, which shall serue to prime it with  
powr

powder-dust, moystened with oyle  
 of petrole, onely it is to be noted that  
 the touch-holes of the little barrells  
 be made somewhat large, to the end  
 that the rust stop them not, being  
 long time kept amongst the salt-pe-  
 ter, and so they may be conserved  
 many yeeres, and ready for service  
 in all occasions, the figure C. doth  
 demonstrate the granad perfect and  
 burning.

## CHAP. II.





## CHAP. V.

*How to make fiery arrowes.*

**A**voyde all confusion,  
 I will treat first of all  
 the fires which are cast  
 with violence, and af-  
 terward of those which may be cast  
 out of mens hands. And first it is re-  
 be observed, that fiery arrowes are  
 of great effects and noysome at sea,  
 specially if the ships approach any  
 thing neere, so that they may bee  
 shot or cast into the sayles, chording  
 or wood of the ships, either by cross  
 bowes, long bowes, or any other  
 meanes, for so much as a ship being  
 one

once a fire, hardly can it be extinguished. And thus the arrowes ought to be made: first a long shaft of wood, and ioyned to it an yron head made after the manner of the figure A, and about the middle of that head, make fast a linnen bag in the forme of an oliue, leauing open a hole at the end before, as may be scene by the figure B, that it may bee filled with the composition following. Take one pound of Saltpeter, halfe a pound of gunpowder-dust, and halfe a pound of brimstone in povvder: all these ingredients being well mingled, and mingled with oyle of petrole, then fill the bagge round about the arrow head, noted by B, and then let all be well bound about with wyre. And for the priming of these arrowes, dip

cotten weeke into gunpowder, wet  
with water, but let the cotton be wel  
dried again before it be applied to the  
arrow head. Now for the ioyning



of your arrow head, to the wodden  
shaft it ought to be so slightly fast-  
ned to it, that being shooke into any  
sayle, cordage, or wood, so that if a



ny one would plucke it backe, the shaft should slip out of the head, and so continue burning in the place pretended, and to hinder that one may not pluck out the head with their hands, there may be made a small hole quite through backward, and so the fire will hinder a man from touching any part thereof, although it should sticke in other of his fellowes clothes. There may be made little arrows of the same fashion, to be cast out of mens hands in any meetings, assaults, breaches, or other occasions; and if there shall be great hast for the making of them, lesse fashion may serue, hauing onely little stickes of wood, about a foote and a halfe long, and in stead of the head prescribed, a pyke (like a great nayle) and in lieu of feathers,

pieces of past-boord, stucke into the ends of the wood being slit, but the former composition shall be required.



## CHAP. VI.

*How the granads are to be charged into the mortar.*



Although it seeme to be but a small difficulty to charge the granads into the mortar, yet it is the greatest mastery and most curious worke which hath beene found amongst fireworks, and the most industrious  
Engi-

Engineers that ever I yet saw, haue after beene deceived therein, and shot out their granads, they not taking fire, which is absolutely one of the greatest faults that may be committed. Then to avoyde such great errors it shall be needfull to note many obseruations following, whereof the first is that you put not too much powder in your mortar, marked A, but onely the powder sacke full; secondly, that the priming of your granad be firme, not spoyled with dust or dyrtie moistnes, or other like thing, that it bee not also too dry, least all breake about your selfe going out of the Morter taking fire too quicke, which all fire-works are very subiect to doe, then take heed that the granad enter not too hardly into the mortar, which will  
cause



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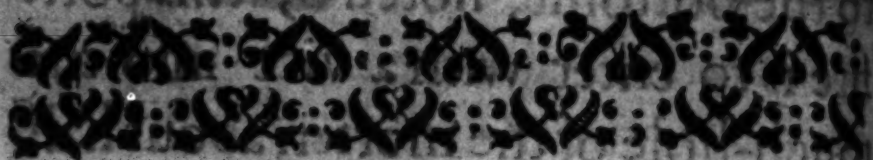
cause it to breake in the discharging,  
also it is not needful that it enter too  
loosely. All these things being well  
observed, you must haue alwayes rea-



(dy port-fires for your mortar, which  
may be made about the bignesse of  
your litle finger, and hollowed with-  
in about the bignes of a quill, even

to the bottome, noted B, this port-  
fire is to enter with a vice into the  
touch-hole of the mortar, about half  
an inch, and to turne the vice with-  
out any key: there may be made 4,  
buttons at the out-side of the vpper  
end, and let this portfire be charged  
with a slow composition, mingling  
4. ounces of charcoale with a pound  
of powder-dust, this being done, and  
your granad placed in your mortar,  
so that it shake not, close vp the  
chinks round about your granade,  
within the mortar, with greasc, waxe,  
pitch & greasc, or any such like thing  
you may so cover the granad with  
some such stufte, that in any weather  
wet or dry, you shal find no difficul-  
ty to shoote off the granad in any  
place whereſoever you please.

CHAP.



## CHAP. VII.

### *The manner how to shoot the granads.*



Here is no lesse difficultie well to discharge the granads then to charge them, but the contrary will easily appeare, for it is there where the hazards and dangers most great, doe meet together. And the first of all are the aduersaries Canons from whose dangers the Enginier shall easily conserue himselfe, as followeth, causing to be made a trench like vnto an halfe moone, the connexity thereof being towards the enemy



enemy, as appeareth by the figure A,  
this trench shall be of such bignesse  
as the Engineer may conveniently  
place all such things as shall be need-  
full for his present vse. The second  
difficulty following, is how to shoot  
them right to the places of any Fort  
or Towne desired, being not possible  
to see the places to take leuel at them  
without eminent danger of their  
Canon and musket shot: which dif-  
ficultie shall be thus auoyded, and  
yet leuel right, and send the granads  
to the places required: let there bee  
be two staues set vpright, betweene  
the Towne, Fort, or Cittadell and the  
Trench, the one of these staues shal  
be somewhat long, the other may be  
short, and that planted vpon the  
brim of the trench, but the longest  
somewhat distant in a right line to-  
wards

wards the place pretended, as doth  
demonstrate the figures BC, these  
staues shall be so disposed that you  
may see the extremities of each, be-



ing in the trench out of the enemies  
sight, and by the sight of these two  
extremities, you may direct your gra-  
nads at your pleasure inclining your  
[morter-

morter-piece vpon either side, as shall  
be needfull without danger of the ene-  
mie, having onelie knowne the di-  
stance betwixt the trench and the  
towne, or place of the towne which  
you shall desire to destroy. The third  
and last difficultie is to know the true  
length or distance that your mortar  
doth beare, of which to be certaine,  
you must trie it before, shooting gra-  
nads of the same weight, & with one  
sort of powder, and with a leuch, take  
seuers sorts of elevations, & so may  
you know such an elevation doth car-  
rie so far, and such carie so far with  
such powder such a weight, || being  
charged, the maner of taking these e-  
levations is represented by the figure  
D, & the level in a bigger volume by  
the figure E, this leuch being placed  
vpon the mouth of the mortar piece,  
and vn-



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vnder the foot thereof: wedges, you  
 may giue to the mortar what incli-  
 nation shall be required: and to be  
 sure from all harme of your owne  
 granads, which by chance may breake  
 going out of the Morter-piece, let  
 there be made in the trench a little  
 corner hollow into, or behind the  
 which you may alwayes retyre, ha-  
 ving given fire to the Morter. It shall  
 be also needful that some one watch  
 where the granad doth fall whether  
 too short or too farre; that you may  
 the better direct the next shot: this  
 method is to be observed in shoo-  
 ting all sorts of granads, stones, &  
 other like things.



CHAP. VIII.

*A most violent method to set a Towne  
on fire.*



hitherto there hath not  
been found any means  
or inuention more cer-  
taine or violent, where-

by one might conuey fire for the de-  
struction of the enemies habitati-  
ons then by the helpe of the prece-  
dent granads, which very hardly  
caule any disorder or combustion,  
vntill amongst houses covered  
with straw, whereof few are to be  
found in goodly townes. And there-  
fore I will here prescribe a new way

D

much

much different from the others before written; against which hardly or not at all may be made any resistance or possibilitie for defence, the violence, rage, and order being of such a fearfull power and execution, provided that the Enginier doe but meanly effect his purpose & designe, and for the practise hereof, let there be made a kind of well in the ground but sloping, as doth demonstrate the figure A, of such deepenesse as shall be thought fit, but it is to be noted, that the neerer you are to the towne, the lesser sloping will be best, and most easie for the performance. The hollow pit or well being made, let there be placed in the bottome thereof one or two barrells of gunpowder, as shall be seen needfull, according to the proximitie or  
dis



distance betweene the place and  
towne, & these barrells may be places  
very conueniently placed with good  
store of straw about them to keepe



them from the moystures of the  
earth. And in one, or else in both,  
you shall place a gunlocke, making  
fast to the clicket thereof a chaine of

sufficient length to reach out of the hole vpon the plaine ground, but this chaine shall be curiously lodged in a small gutter, which afterward shall be covered with earth, to the end that the fire doe not ouer-heat it, then cover the barrells of powder with strong wooden planckes, or broade stones, covering them againe with earth, and then lay good store of fresh straw and bauins, and fagots, and in the midst of these let there be placed a great fagot, made of peeces of timber, of a reasonable length, being well bound together with chains of yron in three or foure places, as doth appeare by the figure B, and then set fire on the straw, wood, and all that shall be in the pit, giving the great wood time to kinde, and this great fagot being in a great

great order, let the chaines be drawne which are tyed to the latches of the gunne lockes, and doubtlesse you shall see braue sports; and if there be many pieces of Ordnance about the towne or place thus besiedged, let them be all disposed ready to shoote where this great fagot falls, and who-soeuer would but this inuention in practise, ought to make many of these parts about a towne, giuing fire to them all at once: but the Inguiner to know iustly how far these great flaming fagots may flye, the hollow pit declining so many degrees, hee ought to make tryall before in some large place, where he may haue room for his experience: now resteth only to explicate how a man may giue fire to the stau in the pit without danger, for so much that euery man



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would not least all should take fire together. Then to be free from this perill, it may be fired by a traine of powder, by a Gunlocke, a piece of match, a candles end, or other like inuention: Peradventure, you may thinke that there may be danger in drawing the chaine when all is on fire; to which I answer these may be ioyned to it, a chord of such length as shall seeme necessarie; The Engli-  
 nier who shall put this in practise, may adde of his inuention what hee thinkes fit, *Facilius est enim addere in-  
 vento quam inuenire.*

CHAP.



## CHAP. IX.

*How to make Granads to cast with  
mens hands.*



Having taught how to  
make Granads for the  
Morter, which by the vi-  
olence of that most won-  
derfull instrument may be transpor-  
ted very farre over waters, walls, or  
bulwarks, working strange and  
rude executions or effects, I will now  
shew how it shall bee easie to make  
two or three sorts of Granads to bee  
cast out of mens hands, the effects  
whereof are no lesse to bee esteemed  
then the other, chiefly in assaults,  
D 4 whether

whether it be for the offendants or defendants. The chiefeft and of greateft operation is made of any kind of bricke mettle as the precedents; and their fabrication is not much different from the other, onely more rounder and lesser, and the single ones having a long neck to seem for the Port fire, as doth appeare by the figure A, and first of all the granad is to be filled with fine gunpowder, and afterward fill the neck with a slow composition as followeth. Take 1. pound of gunpowder dust, two ounces of charcoale dust three ounces of saltpeter, all these well mingled together, fill the port fire required, but this mixture must be well beaten into the port fire and the granads being thus finished, they may be kept a yeare, ten yeares, yea twenty



if need be. It is to be noted that  
these granads must not be fired vntill  
a man is ready to cast them a-  
way even in the same instant, be-



cause the port-fire being consumed,  
the granad breaks in divers pieces,  
and each piece sufficient to kill ey-  
ther man or beast, and therefore the  
hand.

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handling of them is somewhat dangerous. The second manner of Granad to bee cast out of the hand, is made also of bricke mettle, but hath no necke for a Portfire, but is onelic round, hauing in one side a hole as appears by the figure B, and at this hole it is to be filled with drie powder, and then is to bee put into this hole to stop it, cotten wicke made as followeth. Take good Gunpowder and steepe it in faire water, and being dissolved, take the cotten wicke and steep it in the Gunpowder dissolued, which done, hang it out to drie; but let it be doubled eight or ten times, to the end that it may the better receive the powder, and being drie, cut it in such pieces as you shal need, putting the one end into the Granad at the hole, and then put that Granad into

into another pot a little bigger then the Granad, as appeareth by the figure C, so that you may put a little drie powder round about the lesser Granad betweene the pots and Granad, then cover the mouth of the last earthen pot either with leather or such like stuffe, and bind it round about with wyre, but first put the wire through pieces of match about halfe a foot of length as may appear by D, and when you desire to make vse of this sort of granad, set on fire euery end of these pieces of match, and cast the pot away, which falling either vpon the ground, or anie souldiers Armour, you shall see the earth-pot breake, the Granad split, and worke such furious effects, cyther at a breach or anie approach. The third sort of Granad is made much



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muchlike to either of those prece-  
dent, except onely it may bee made  
double or single, of glasse or of earth  
onely shall be needfull to be made  
very thicke, and if it be to be made  
single, the portfire ought to be either  
of wood or of pastboord, and well  
glued in, and this last sort may work  
great effects. Now having somewhat  
largely treated of the mortar, gra-  
nads, and of their vse, I will speake  
a little of other oylly fireworkes very  
pernicious and noysome to all assai-  
lants.

CHAP.

## CHAP. X.

*How to make fiery wheeles to be  
cast with mens hands.*

**E**Or as much as euery  
souldier wil not med-  
dle with making nor  
casting out of his  
hands granads, the  
handling of them being somewhat  
dangerous, I will here teach ano-  
ther manner of fireworkes, which  
is not much lesse offense, which  
being well compounded and com-  
pacted, and for the making thereof,  
these are more ingredients required,  
then for the precedents, and is more  
diffi-

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difficultie in making of them as fol-  
loweth, Take foure pound of gun-  
powder in dust, one pound of char-  
coale dust, two pound of tarre, two



pound of salt-peter, and one pound  
of Rosin. All these ingredients be-  
ing well mingled and heat over the  
fire, steepe toyv or flaxe in the same,  
and



And then wrap the tow or flax about  
 a whope, which is represented by A,  
 and then cover all this againe with  
 Gunpowder dust, & in time of need  
 giue fire to them, and cast hem a-  
 mongst your enemies. onelic is to be  
 obserued that the whops or circles  
 ought not to be too large, but falling  
 vpon a many of souldiers they may  
 there stay and sticke, and so make  
 them more troublesome and intang-  
 ling, two may be tied a crosse on a  
 nother, and then falling vpon anie  
 man, he cannot choose but be much  
 astonished with such a fearefull ele-  
 ment, and put his company in great  
 disorder.



...of water dust & in time of need  
...**CHAP. XL.**...

...your enemies. one to be  
**How to make a Shippe of wilde**  
**Fire.**...

...many of soldiers they may  
...**E**ter a sufficient discour...

...of all manner of Gra  
...nads, fierie arrowes and  
...burning wheelles, I can...

not thinke it extravagant, or amisse  
to lay open to the industrious, or cu  
rious, a method how to make a fiery  
ship at sea, which shall not begin to  
burne till it hit against some other  
vessell, rocke, or such like obstacle,  
or be hooked or grapled on the in  
side to be drawne a shore. Hee that  
will

For the first part  
will vndertake to build one of these  
must spare no reasonable cost to put  
his intentions or designes in execu-  
tion, and first of all must be had one  
ship or many, according to the times  
and occasions wherein they shall be  
required; and within the shippe  
shall bee disposed great store of  
broken Canons well charged with  
bullets, and from one Canon to a-  
nother shall be ioyned a port-fire, so  
that the first having taken fire, all the  
rest must needs doe the same; these  
Canons shall haue their mouthes put  
out of the Gun-ports ready to bee  
discharged; this done, let there bee  
good store of dry straw, small dry  
wood, and tow and flaxe steeped in  
pitch, turpentine, rosin, and tarr,  
mingle and wrap the tow thus steep-  
ed, about and amongst the

E

wood



wood and straw, and place it betwene all the Canons; the straw and small wood shall be so disposed, that it may take fire when the best part of the Canons are discharged, and the peece of Canon which is to giue fire to the straw, shall be set with the mouth vpward to blow part of the decke away, and at the same time giue fire to great store of granads of all sorts, to adde musket-barrells to barrells of Gunpowder ranged in order aboue the deck, to blow out these things by order, now one, then another by the helpe of slow portfires, but the beginning of this sport ought to be very violent and furious, to frighten and also teare in peeces the enemies at once, & that therage hereof be the more furious, let the greatest part of the Canons shoot

shoot off thick one after another  
 with the water, and at the same  
 time the Granads shall flye the one  
 after off, the others fall neere, now a  
 barrell of gunpowder blowes out a  
 part of the flaming ship here, and a-  
 gain another barrell caste out a quar-  
 ter of the vessell ardent there, casting  
 divers sorts of fire here and there as  
 balls, arrowes, granads, double and  
 single ones, made of the composi-  
 tion prescribed in the 5. and 10. chap-  
 ters, but to hinder all the barrells of  
 powder from taking fire together,  
 which is no small difficultie, every  
 barrell ought to be plastered over,  
 and then covered with glue and a  
 lincloth, and then put into another  
 barrell, but to make them take fire  
 every one at your pleasure, put a Port-  
 fire vnto the, of such length, & flow.

composition, as you shall thinke fitting. Now to begin this mad sport, fasten three or foure good strong gunlockes within the ship, at one end



of the traine, which is to giue fire to the first Canon, and to every click or tackit of the locks, fasten an yron rod, and let the other end of the



on rod passe through the ship, and  
be made fast to peeces of strong  
wood, in the manner of a gyrdle on  
the outside of the ship, which is re-  
presented in the figure by the points;  
so that touched vpon the outside a-  
ny thing rudely, the locks must needs  
strike fire, and set going all the rest;  
and to make it give fire being hoo-  
ked in the inside, to draw it ashore,  
or out of the way, let there be made  
fast to each clicket of the locks, long  
wyres, and the other ends of the  
wyres may be fastned to pieces of  
wood in the inside of the ship, round  
about the edge, so that the first thing  
that shall touch it, sets all going as  
vpon the outside, but the pieces of  
wood vpon the outside ought to be  
very neere the water, as doth demon-  
strate the figure with the points, and

to conduct this ship as neere to the  
 place as may bee, without danger  
 there may be fast ioind to the stem  
 piece of timber noted A, B, to the end  
 whereof may bee fastned two long  
 ropes, and to them two little boats,  
 which men shall be for the conducting  
 therof. This here is but a sparke  
 of inuention, to which the industri-  
 ous Enginier shall adde of his what  
 he please, and take this but for an en-  
 try of such workes; for although  
 haue here set downe gunlockes, to  
 giue fire to the Canons, my meaning  
 is that they bee made like gunlockes  
 but ten times stronger, and harder in  
 going off, leauing to the iudgement  
 of the discret Enginier, the true dis-  
 position of his owne designs.

## CHAP. XII.

*How to make a Petard.*

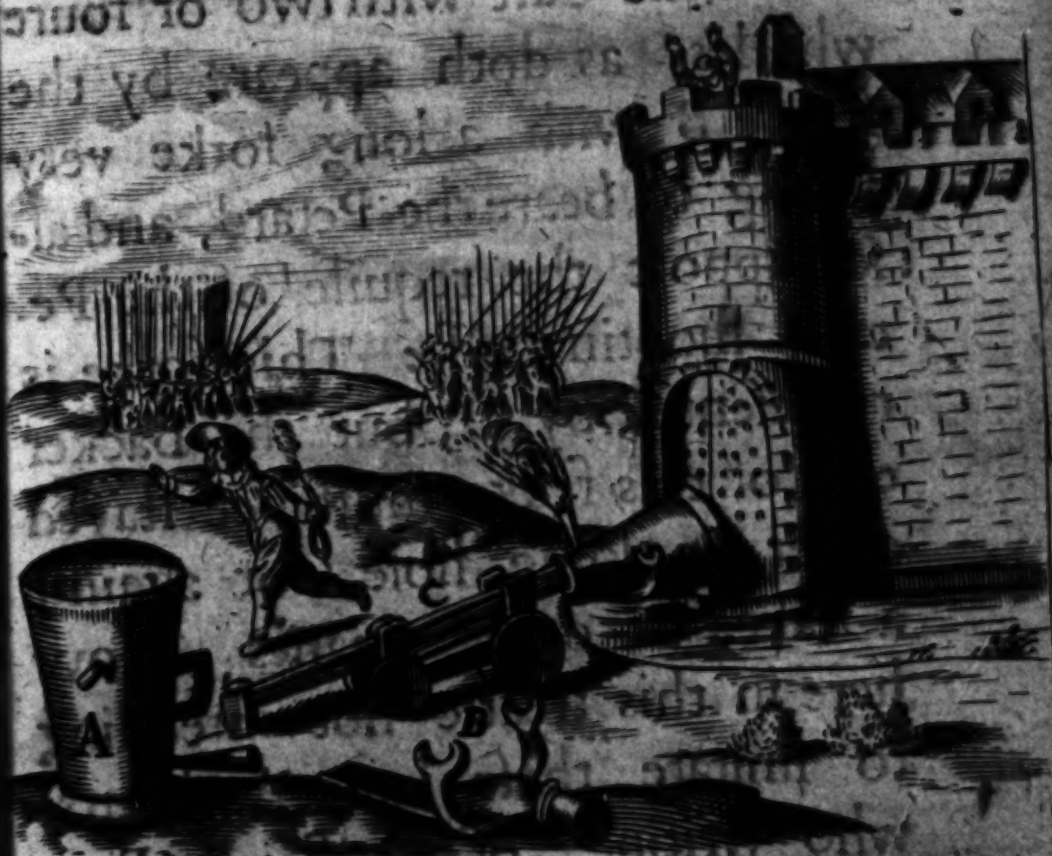
**D**iego Ufan, a Spaniard,  
 Francis Tibourelle a Lo-  
 rcine, and Master Ro-  
 bert Norton an English  
 man, hauing al written of fireworks,  
 and neither of them all vnderstan-  
 ding how to charge a simple Petard,  
 I thought fit to end these fireworks  
 for wars by the description of the  
 same, that being of great violence to  
 make entries & breaches into towns  
 castles, or houses, the mortar prescri-  
 bed, may serue to petard a place



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as hath beene sayd already: but who-  
 soever would make exactly a Petard,  
 ought to cast a Morter much like  
 vnto an Apothecaries mortar, as  
 doth represent the figure A, obser-  
 ving the rules following, if you make  
 it, to weigh fixe pound of mettles, let  
 the caliber or bore be of such big-  
 nesse to containe one pound of pow-  
 der, or one pound and a halfe: if you  
 adde or diminish more or lesse met-  
 tle, augment or diminish the caliber  
 likewise, to hold the fourth part of  
 powder which the mettles doth  
 weigh; and for the charging of the  
 Petard, fill it only with the best gun-  
 powder you can, almost to the brim;  
 and then couer it with a round board  
 made fit for the purpose, leaving a-  
 side all frivolous directions, written  
 by others beforenamed; and for the  
 priming

priming of the Petard, make a port-  
fire of slow composition, as for the  
precedent fireworkes of what length  
you please; and to breake open the



place you desire if it bee accessible,  
then with the heele or breach of the  
Petard vpon the ground or some  
great stone or piece of wood, and the  
mouth

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mouth against the part of the dore,  
gate, or elsewhere, which you shall  
iudge fittest, but if the place bee  
unaccessible, then make a kinde  
of a little Cart with two or foure  
wheelles, as doth appeare by the  
figure B with a long forke very  
strong to beare the Petard, and al-  
so support the requile of the Pe-  
tard shooting off: This forke is  
represented by C, but the backer  
end of this forke must bee stayed  
either in some hole, or against  
a stake, or other meanes; Now  
here in this treatie not intending  
to imitate these late Authours,  
who writing of artificiall Fire-  
workes, have prescribed natures  
and compositions of almost all  
manner of drugges, the meanes  
whercof



whereof may bee found in anie  
Apothecaries shoppe; doubtesse  
eyther to perswade the curious  
Readers that they had profound  
knowledge, many rare secrets, or  
else the better to hide their igno-  
rance, by that great confusion  
and expence, whereunto few or  
none would extend and vse their  
purses to make prooffe and expe-  
rience of. I will finish this trea-  
tie of artificiall Fire-workes for  
Warres, and goe forward to the  
second treatie of Fire-workes for  
pleasure and recreation, and ex-  
plaine in the Preface apologitike,  
for what vse all these vnknowne  
dregges are fit for, which seemes  
to those that are ignorant of such  
rare and wonderfull effects. As  
Selar-

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Salarmoniacke, Antemonie, Arse-  
necke, Vitrioll, Stonelime, Thutic,  
Adamant stone, not forgetting quick  
silver.

THE



THE SECOND  
TREATISE OF ART-  
ificiall Fire-workes for  
pleasure.

CHAP. I.



Erspicuous & plain  
shall be the method  
to make all manner  
of Fire-workes for  
pleasure, (which  
heare I will set  
downe. for the contentment of all  
curious and ingenious Artists) with-  
out such a number of vnknowne  
dregges for mixtures, as many here-  
tofore



tofore haue prescribed more fittest  
 for some prodigious actions, then to  
 mingle for artificiall fireworkes; and  
 principally for those which are in-  
 vented for pleasure, for these haue  
 no need of venomous smoaks to poi-  
 son the Spectatours, making mirth  
 turne to mischief (which notwith-  
 standing cannot be done in an open  
 ayre) neither haue they need of such  
 a continuing, ardent and violent  
 flame, as to consume Cities or habita-  
 tions; but onely of a gentle and plea-  
 sing flame to the eyes of the specta-  
 ctors; and thus they are divided in-  
 to three sorts. The first are those  
 which ascend and mount into the  
 ayre; The second are such as con-  
 sume vpon the earth; The third  
 and last sort, are those which swim  
 and burne in the water. Those which  
 worke

work to their effects in the ayre, are  
 likewise divided into three sorts, the  
 chiefest and most noble of all are the  
 ballouns; The second the rockets,  
 and the third are flying faucissouns,  
 those which stand fixt vpon the  
 ground are also distinguished into  
 three sorts; The first are the rockets  
 for the ground, the second the fierie  
 lances, and the third faucissouns: The  
 first for the water, may haue their  
 triple diuision; globes or balls make  
 the first, double rocket; the second,  
 and single ones the last; and to treat  
 of euery one in particular, I will begin  
 with the rockets for the ayre; and  
 first of all describe their moulds, and  
 the measures which must be obser-  
 ued in making of them.

CHAP. II.

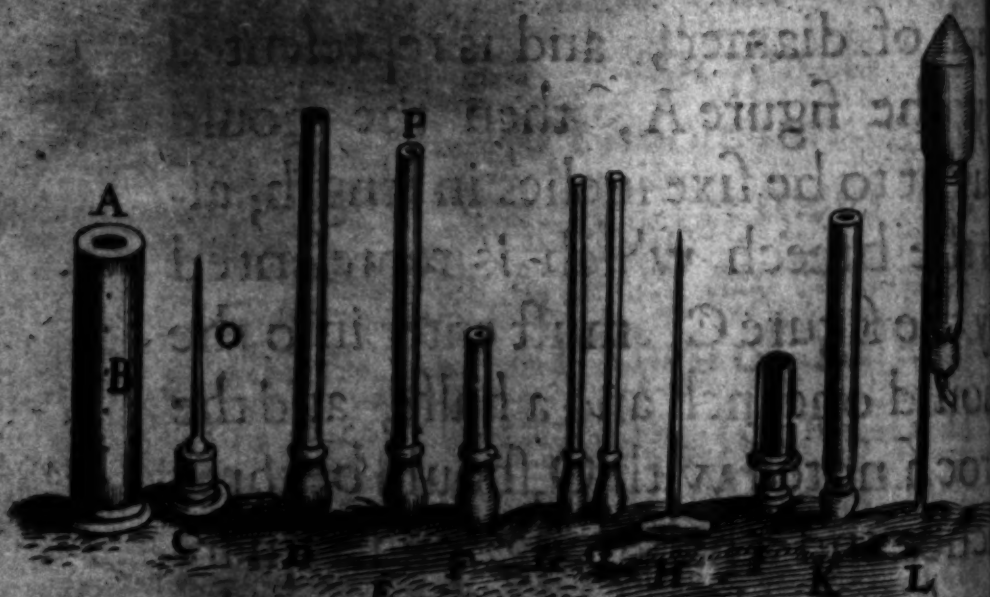
*A method to make moulds for rockets  
for the Ayre.*

 Although that balloun  
are absolutely the  
most noble sort of fir  
workes, yet for so much  
as all great fireworkes are composed  
rather of rockets, then of balloun  
I thinke it conuenient, to begin the  
second treatise with these; first of  
making the description of the  
moulds, which may bee made either  
of brasle or wood, the one being  
good as the other for vse, if the me  
sures following be obserued; which



shall be convenient for all sorts of  
 gnesses, because they depend one  
 upon the caliber or bore, and that  
 being enlarged, the other parts will  
 be all enlarged also, that being dimi-  
 nished, all the rest will be diminished  
 likewise. Then to make a mould, the  
 caliber wherof shall be supposed an  
 inch of diamer, and is represented  
 by the figure A, then the mould  
 ought to be fixe inches in length, al-  
 the breech which is represented  
 by the figure C, must enter into the  
 mould one inch and a halfe, and the  
 roch noted with O, should be three  
 inches and a halfe long, and a quar-  
 ter of an inch in bignesse, and the  
 wvler D, which is to rowle the  
 cartoush or coffin of paper vpon,  
 shall be three quarters of an inch in  
 gnessse, & the rammer E, to charge  
 F and

and ram the rocket, shall be some  
what lesse then the rowler, to the end  
that it may enter easily into the can-  
tough or coffins.



Also it shall be made hollow,  
deepe as the broch is long, as doe  
appeare at P, because the rocket must  
be loaded, the broch being in it,

For the massif marked with F, shall be of the same bignesse as the charger. The 2. other rowlers noted G, G, or to make serpents, as shall be instructed hereafter, and the bodkin H, is to make holes through your starres, as shall follow, the Lanterne I, is proper to charge the composition into the rockets. The figure noted K, is the cartoush or coffin ready to be charged, and by the figure L, is represented a rocket quite made. This method prescribed may be observed in all sorts of moulds; for if you would make one lesser, as of halfe an inch, the caliber or bore, then the length must be 3. inches, which is 6. halfe inches, the breech shall enter 3. quarters of an inch, the broch shall be an inch 3. quarters long, & the rowler or the cartoush shall be half a quar-



of an inch; but if you make the caliber of two inches of diameter, the mould be 12. inches in length the breech shall be 3 inches, and the broch 7. inches of length; and so for all the other parts appertaining to the mould. Now followesthe description and manner how to make a rocket.

The figure noted K. is a rocket of a common ready to be used, and by the figure L. is a rocket of a rocket quite ready. This rocket described may be obtained by the use of moulds, for if you

ould make one of these of brass in the caliber of three, then the

rocket shall be of three inches in diameter.

of an inch, the broch shall be

of an inch, the broch shall be

of an inch, the broch shall be

## CHAP. III.

*How to make a flying rocket for  
the Ayre.*

**F**Or to make the mixture or composition of all middle-sized rockets, take a pound of gunpowder finely bruised and boulded with two ounces of charcoale-dust, mingle these well together, and try one rocket, which if it breake, adde more charcoale dust to the composition; but if the rocket doe not ascend, beeing weak, adde more powder dust boulded as before said; and so shall you

F 3      make

make your composition stronger or weaker according to your desire; instead of charcoale, you may put sea-coale, saw-dust, or any other like thing, so that you keepe a Medium not putting too much nor too little which thus you shall know if the rocket mount not, you haue added too much coledust; but if it breaks you haue not put coledust enough for the charcole-dust which you put into the powder dust, is onely to moderate the violence of the powder and to make the rockes tayle appeare more beautifull; which sea-coaledust has well as charchoale, and charge the rocket with this composition as it ought to be many rules are required of to be obserued; and of al that in charging the rocket, you put not too much composition at once in the cartoush or coffin; 2., that



be beaten with a mallet 3. or 4. good strokes; and then put new composition thereupon, beating it again with blowes as before; and thus putting in at severall times the quantity of one or two spoonefulls, at each time beating it well with a mallet, and let not the cartoush bee filled higher then the mould, but being iust full thereto, then double downe halfe of the paper with the bodkin beating it (as the composition before) & at last pierce 2. or 3. holes with the same bodkin to the powder to giue fire, to either stars, serpents, or fauceffous, as shall be taught following; and these holes are represēted by C, let the rest of the cartoush be cut even with the mould, and thus must be made all sorts of rockets, great or little ones. It is to be noted, that the composition prescribed is fit; for all sorts of

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rockers, great or little, but onely  
must be made weaker for great ones  
then for little ones, adding more  
charcoale to it, for the whole secret is



in making the composition neither  
to strong, nor to weake, and not as al  
writers hitherto haue thought, fol  
lowing each one the others errors,  
thin-

thinking that the true manner of making excellent rockets, is to put many ingredients into their compositions, wherein they have all erred absurdly; and last of all Master Norton, for absolutely the best composition is, that which is made of fewest ingredients; and the rockets made thereof may be kept many years, and good at all times.

**CHAP.**





## CHAP. IV.

*How to make moulds for Rockets  
for the ground.*



He mould must bee o-  
therwise made then the  
precedent, because such  
violence is not requi-  
red in these, as in those which mou-  
into the ayre, but onely of somewhat  
longer continuance; and therefore  
these measures following shall serve  
at all times, neuer being made bigger  
nor lesser, but alwaies the same for all  
occasions. Let the caliber behalfe an  
inch, the diameter; and 5. or 6. inches  
of length; and the rowler for the car-  
toush

touth shall be foure lines in diameter  
 which is the third part of an inch, and  
 the rowler to charge withall some-  
 what lesser to enter without spoyling  
 the cartouth: next let not the broch  
 be longer then  $\frac{3}{4}$  quarters of an inch,  
 and the breech shall enter halfe an  
 inch into the mould; and the cause of  
 this great alteration is, that the rock-  
 ets which mount into the aire, haue  
 need of great and violent strength;  
 and by consequence last not long,  
 but wee desire that those vpon the  
 ground may dure a long while, with  
 a gentle motion, which shall be easi-  
 ly performed, the rules following be-  
 ing obserued.

CHAP.



# CHAP. V.

*How to make the composition for rockets  
upon the ground.*



His is the easiest composition of all others, for in this shall be nothing required, but onely Gunpowder well beaten and boulded, so that it be as fine as flower, and then fill your rockets by little and little, well beating it into the cartoushes or coffins with a mallet, as the rockets for the ayre, and being full within an inch of the brim of the mould, double downe one quarter of the paper, or cartoush, beating or pressing it with

3.or



3. or 4. good strokes of the mallet,  
and then with your bodkin, pierce a  
hole to the composition; which  
done; put into the cartoush about  
the charge of a Pistol, of good gun-  
powder, and then double down the  
one halfe of the cartoush, giuing a  
gentle blow or two with the mallet,  
& with a smal cord, or big line, choke  
the rest, and what shall rest aboue  
the choaking, cut it off, leauing a pi-  
ked point, as appeareth by the figure  
E, in the 31. chapter of this Treatise;  
and your rocket being thus finished,  
and primed with a little wet pow-  
der, and layd a drying, shall be ready  
for all occasions.

CHAP.



## CHAP. VI.

*The manner how to make  
Serpents.*

**H**E Serpents are to bee made eyther of the composition for rockets on the ground, or of that for the ayre; for being filled with the composition fitting for the ground, they will spreade and sparkle liuely in the ayre, but if filled with the other composition, they will fall weaving neerer together; notwithstanding

standing eyther sort will shew di-  
vers pleasing actions in the ayre,  
being made as followeth. Let the  
cartoush be about foure inches long  
and rowled vpon a rowler, some-  
what bigger then a goose quill, as is  
represented by the precedent figure  
G, in the third chapter, the paper  
ought to goe about the rowler nine  
or ten times, and then choaked al-  
most in the middle, yet leaving a  
little hole to see through, and the  
longest part shall be filled with the  
composition, but the shorter with  
fine grayned powder, and choaked  
close; also the longest end must  
bee halfe choaked close; as doth  
appeare by the figure F, chapter third  
but if you desire not to haue them  
wamble in the ayre, then let them  
not bee choaked after the compo-  
sition



position, but as doth represent the figure G, both which figures, F, G, represent Serpents quite finished.

and rowled upon a rowler, some what bigger then a goose quill, as is represented by the precedent figure G, in the third chapter, the paper ought to goe about the rowler nine or ten times, and then choked al-

~~the hole to be through, and the~~

longest part shall be filled with the composition, but the shorter with the CHOKED powder, and choked close; also the longest end must bee halfe choked close, as doth appear by the figure F, chapter third but if you desire not to have them wamble in the eye, then let them not bee choked after the composition.



## CHAP. VII.

*How to make golden rayne.*

Any there are (specially in France) who make rockets, yea and boast that they are perfect therein, who know not what golden raine is, but thinke it to be some other thing then it is; wherefore to put them out of doubt, and to teach all others who desire the knowledge thereof, I will here set downe the description and maner how to make it. Take goose quils, and cut off the hollow ends, leaving them as long as may be, as the figure K, doth demonstrate third

G

chapt.

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chap. and fill these quilts with the composition of rockets for the ayre, at the last stopping euery one with a little wet powder to keepe in the dry powder, & crowning a rocket with these (as shall be taught following, chap. 12. in its true place) will shew a most glorious & pleasing raine, w<sup>h</sup> some hauing in times past seen, haue called it golden rayne for the beauty thereof, but of later times it is more commonly called golden hear: many beautifull and strange figures may be represented in the ayre, with this manner of rayne, as shall follow in the 13 chap. treating how to represent many sorts of figures in the ayre with rockets.





## CHAP. VIII.

### *The manner how to make Starres.*

**A**lthough that there bee many sorts of compositions for stars, yet I will set downe here but two of the best; all the rest being nothing worth, but friuolous and expensiuē: the first and best sort, is to be made of dry powder, and the other of moistened powder as followeth. For the first take 1. pound of saltpeter, halfe a pound of brimston, and a quarter of a pound of gunpowderdust, all these being plucised & mingled together,

G z

wrap

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wrap the quantity of a nutmeg in tow in a linnen rag, or in paper, and bind it fast, as appeareth by the precedent figure H, chap 3. and to prime them, you must pierce them with the bodkin, and put stoupell or cotton wicke dipt in powder through them (which shall be made as followeth in the 11. chap.) and to make the second sort, take 1. pound of saltpeter, and halfe a pound of powderdust, and halfe a pound of brimstone all these wel pulverised and mingled together, moysten them with eyther oyle of petrole, or els with fair water onely, to make a past of them, whereof make little balls about the bignes of a musket bullet, and whilst they are moist, rowle them in dry powderdust, then let them dry, and then may you employ them at your pleasure, with.

without further trouble; for the last powder in which they are rouled, doth serue for their priming. This last sort of starres doth not make so beautifull a shew in the ayre as the others, for falling downe, the flame of them takes the forme of a lampe, hauing no force to expel it like wings as the others doe, for the flame of the others blowing out of the two sides pierced, make it stretch in length, and by that meanes shew greater in the ayre.

G 3

CHAP.





## CHAP. IX.

*How to make Starres giuing great  
Reports.*



**T**O make Starres, that each one shall giue a report like a Pistoll or bigger gunne, you must first make little saucissons (as I taught in the chapter following, but the saucisson need not to bee couered with chord) and being made and pierced, take as much of the former dry composition, and bind it to the end of the saucisson which is pierced, making a hole through the composition, and passe a piece of stoupell or cottenwicke

wieke as in the other starres; but if you take of the moylt composition, you may onely leaue the paper hollow at the end of the saucisson, fitting to contain the quantity of composition required, putting a little grained powder before, and prime thele starres as the others, of the same composition; these starres are very troublesome and little in vse, because that a great rocket can carry but few vp into the ayre, and by consequence worke but a small effect, and moreover they are very long in making. One may make Starres in the same manner, which ending, turne to serpents and others as shall please the workeman.

## CHAP. X.

*The manner how to make Saucissons.*

**I**N this chapter, my intention is not to treat of the saucisson which flies into the ayre, but only of that which stands firme in great workes, or else which is applyed to rockets, which thus is made as followeth; you must haue a rowler of such bignes as you desire to haue the concauity of your saucisson, wherupon rowle as much paper as you please, and then choake

it



at the one end; which done, fill it  
with grayned powder, & choake the  
other end also, and cover all the sa-  
uiffon from the one end to the other,  
with small chord, as doth represent  
the figure I. chap. 7. and glue that  
cord with strong glue all ouer, and  
when you would make vse of these  
sauciffons, pierce them at the end  
with your bodkin, and put into the  
hole a quill filled with fine powder  
dust, which shall serue for a portfire,  
and the other end of the quill shall  
passe through a board, whereupon  
you meane to fasten them, and shall  
enter into a portfire in the other side  
of the wood, which shall be fastned  
all along the wood, and so may you  
fasten what store you please neere  
together, or farre asunder, this quill  
is represented by the figure L, and  
by

by this meanes one end of the powder  
 fire beginning; all the whole row  
 of faucissons will giue their report  
 one after the other. But if your fau-  
 cisson is to be applied to a rocket,  
 shall onely be pierced at one end, and  
 primed with a little grained powder  
 and fasten it to the top of the rocket  
 either with paper, parchment, or any  
 thing else, so that the rocket, ending  
 the faucisson, may take fire, so shall you  
 not faile of your intent or designe.

CHAP. II. Of the manner of making  
 the other end of the quill shall  
 be through a board, whereupon  
 you may fasten them, and shall  
 be into a port in the other side  
 of the wood, which shall be fastened  
 to the wood, and so may you  
 CHAP. III. Of the manner of making  
 the what fore you please may  
 together, or faire slender, this quill  
 by the figure, and  
 by

CHAP. II.

*How to make Stoupel or preparing  
of your Cotten wieke.*

**T**O make Stoupell, not  
the meanest, but the  
best that may be made  
to giue fire (which in  
proper tearme is called estoupel-  
ing) to all manner of fire-workes.  
Take Cotten-wieke, and double it  
soft as shall bee needfull for your  
use, as if it were to estoupel your fie-  
lances; then double it eight or ten  
times, and also for the stoupling of  
great



great rockets ; but if it bee to p  
through your starres , then 4 or  
threads shall suffice; so having do  
led your cotten wicke fitting for y  
purpose, steepe it in faire water ,  
then wring it betweene your hand  
and take gunpowder dust, with  
other mixture, and steepe it in  
water, not putting too much wa  
nor too little, but onely till it app  
like dirt, and then put into it y  
cotten wicke, and there turning  
winding it till it hath sufficiently  
ken powder in euery place and  
cell, then draw it out, putting a li  
dry dust vpon it, & hang it a dry  
in the sunne or els where, and  
being dry, you shall haue the m  
excellent stoppel that may bee ma  
for your yse at al times, leauing al  
all such ingredients which ignora  
esteem

come so highly of, as Aqua-vita,  
 te wine, strong lee, quick-lime,  
 ger, vrine, and diuers others, for  
 ch I would not lose so much  
 e time as to repeat them, but  
 v goe forward, and shew how to  
 nc all the parts of a rocket.

**CHAP.**



## CHAP. XII.

*The manner how to assemble and set together the parts of a rocket.*



When the rocket is finished and taken out of the mould noted A, in the figure of the 3 chapter, and the rocket is noted with the letter C in the same figure, then must you ioine to the end of the rocket, which is not choaked an empty cartouche coffin, much bigger then the rocket is large, which is represented by M in the same figure, in this cartouche you shall put your serpents, golden rayne, starres, faucissions, or other things at your pleasure, but first of

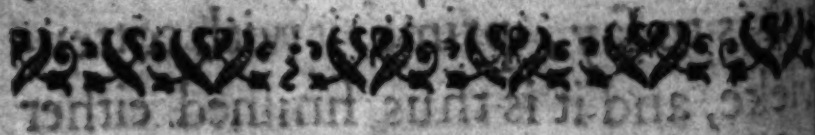
yo



You must put in the bottome powder dust; onely enough to couer the bottome of the large cartoush; and then put the serpents with the ends downeward which are to take fire; and likewise the golden rayne in the same manner; but it is the custome to put a little powder dust amongst the stars; this cartoush being thus filled, couer it with a single piece of paper, and afterward paste vpon that a picked cap made also of single paper, and to make perfect your rocket you must binde a rod of such length and waight, that being bound to the rocket, it must weigh down the rocket on your finger being neere to the rocket, and then stoupe your rocket, that is to say, prime it with cotton-wicke, and it is thus finished either to fire or keepe.

This

This method is fit for all sorts of rockets, great ones or little ones, except that little ones must have the vpper cartouch no bigger then the rocket, onely to hold halfe a dozen of staires or serpents, or one saucisson for so much as many beeing fired together, great confusion would happen, if great rockets should be put together, and not prepared otherwise.





# CHAP. XIII.

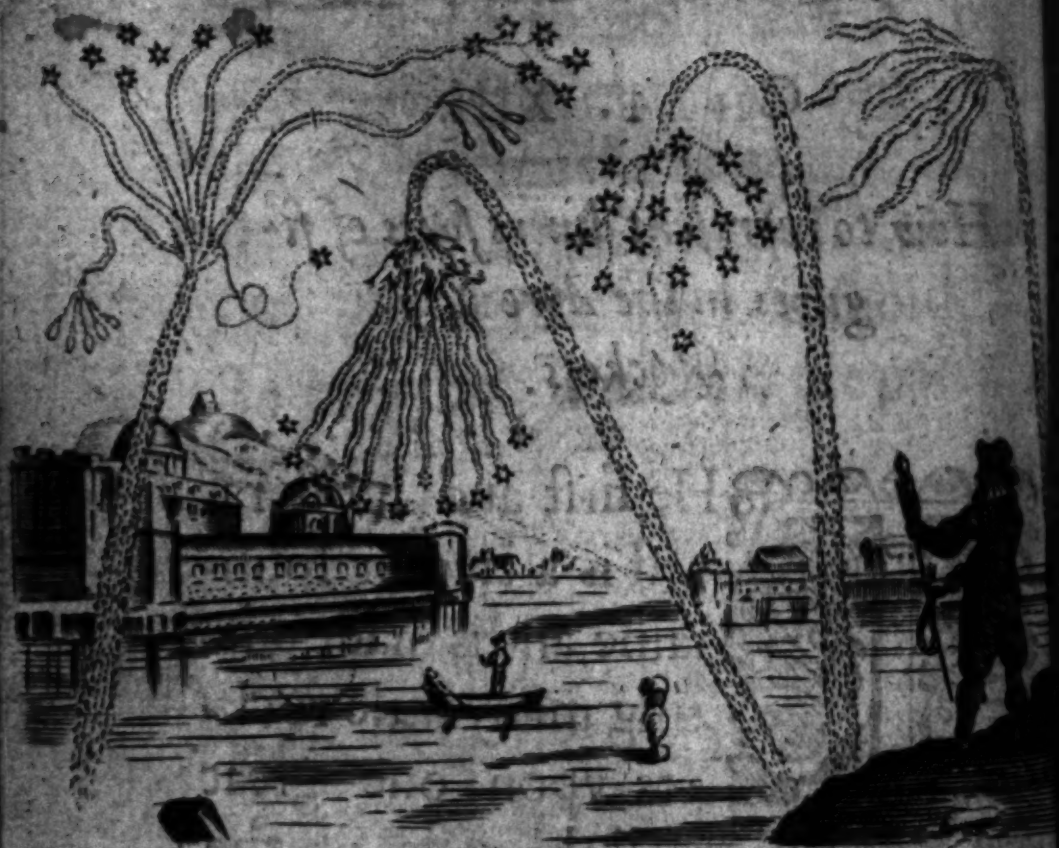
*How to represent diuers sorts of figures in the Ayre with Rockets.*

**T**He first and most rarest is a tree or fountaine, and is made putting many little rockets vpon one great rocket, passing all the rodes of the little ones through the large cartouch of the great rocket, and if the little rockets take fire while the great one is mounting vp, they will represent

H



a tree: but if they take fire when the great rocket is turning downe againe towards the ground, then they will bee like to a fountaine



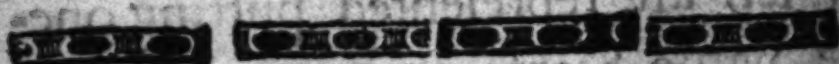
of fire, and if there bee two or three little rockets hauing no rods amongst others they will make diuers motions contrarie to the rest

most

most pleasing. The second figure is the golden rayne; and that is made when manie quills filled (as aforesaid) are put vpon a great rocket; for certaintie all those quills taking fire will seeme like a great shower of fierie rayne to those who are vnder it; but to those who are a side of, like beautifull long haire. The third figure are Starres, which are represented putting one lie manie Starres vpon a great rocket. The fourth are serpents which are alreadye described, but to make all these prescribed figures varie, you may tye manie little ones together by the ends, which take not fire, the quills, or serpents may bee tyed in like manner; but the thread wherewithall they are tyed, must be at least two or three inches

H 2 long

long, betwixt each one, and you  
shall see diuers sorts of figures in the  
ayre, changing themselves into  
much varietie.



CHAP.



101  
A Treatise of Fire-works  
and the reason  
can't it make be made one piece to  
another, they should not take fire all  
CHAP. XIV.

*How to make fierie boxes.*

**T**He fire-boxes are made of many rockets being put into a large cartouſh the bottome whereof is covered with powder duſt, and pierced in the middle to paſſe through a port fire or ſtoupell, to giue fire to the rockets within the cartouſh or coffin, which flying out, leaue the cartouſh moſt commonly whole and vncracked, thoſe boxes are onely to be covered with a peece of paper, that the rockets taking fire may flie out

H 3

with-

without resistance; and the reason  
why they are to bee couered, is be-  
cause if manie be made one neere to  
another, they should not take fire all  
at once.

How to make fire boxes.

The fire-boxes are made  
of many rockers being  
put into a large cartouche  
the bottom whereof is



CHAP.

covered with powder dust and pic-  
ced in the middle to passe through a  
port fire or flourell, to give fire to

the rockers within the cartouche or

cartouche most commonly whole and  
unpacked, these boxes are ordly to

be covered with a peece of paper, that  
the rockers taking fire may lie out

with-  
H 3



# CHAP. XV.

## *How to make fierie Lances.*

**T**He vse of these lances is alwaies required in all great fireworkes, wherefore here shall be described the manner of their making. Their cartoushes are to be made as other cartoushes for rockets; onely these may be made of pastbord, and glued as they are a rowling, if it bee to make great ones; but if for little ones, then paper shall suffice, the cartoushes being made, let them be filled with the dry composition prescri-



bed for starres in the 8. chapter of  
 this treatise, and prime them with  
 wet gunpowder, & the lower end of  
 the cartoush is commonly stopped  
 with a peece of wood, to the end  
 that they may bee nayled or stucke  
 when they shall bee needfull, the  
 wood being about two inches long  
 out of the cartoush.



CHAP.

~~THESE ARE THE SEVERAL KINDES OF FIREWORKES~~

H A

## CHAP. XVI.

*The manner how to make Rockets  
for the water.*

**T**Ake fire & water being two elements of contrary qualities, the one to the other cause the rockets which worke their effects in or vpon the water to appeare to the spectators more beautifull, and seem more rare and admirable, although that all sorts of rockets being fired, will worke their effects vpon or vnder the water, but this onelic is to be noted, that those which are made for

for the ayre, or for the ground, haue  
such strength and force, that beeing  
once kindled and cast into the wa-  
ter, they will consume themselues  
there, and not rise vp swimming as  
those which are made artificially for  
the water as followeth. To make  
good rockets for the water, the calli-  
ber of the mould ought to bee one  
inch of diameter, and in length eight  
inches, the breech to enter one inch,  
hauing no broach; the rowler for the  
cartouch shall be three quarters of an  
inch of diameter, and the charger  
shall be somewhat lesser then the car-  
tough, being ready to bee filled as the  
others. Of two sorts of composi-  
tion, you shall make one as followeth  
(if you desire to make a great fierie  
rayle appeare vpon the water, Then  
take one pound of salt-peter, halfe



a pound of powder-dust, halfe a pound of brimstone-dust, and two ounces of charcoale-dust: but if you desire to haue it to burne cleere like a candle vpon the water, then take one pound of salt-peter, halfe a pound of brimstone-dust, and three ounces of powder-dust, all these must be well mingled together, as all other compositions) and with either of these compositions, fill your cartoush, and ioyneto the vpper end a faucisson, and then couer it all with melted pitch, rofine, grease, or painting, to hinder the water from spoiling the paper: and to make it float and swim vpon the water, bind a rode about two foot long to it as to the others for the ayre. Now if that you desire that this Rocket change

charge his actions vpon the water, swimming now vpon the water, and now vnder the water, put here and there powder dust, powre to the quantity of halfe a spoonfull as you charge it; also may you make it change colour, now red and then white fire, onely changing the composition in filling it, and so the industrious may adde many changes and diuersities as they shall thinke fit: but if you are to make a great number for a great fireworke, then the plainest are the best, onely filling therewith the first composition, but they must be filled two or three fingers breadth with fine powder dust, to make them flye farre off, or else they must be made like rockets for the aire, and afterward charge them foure inches with composition made for water;

but

but to be the more certaine, it is best for those who haue great works, to make to trie one or two before they finish many, that the better they may attaine their designes, which with eie they may accomplish, if the rules prescribed be obserued; for as I think there is not one rule neglected appertaining to the fabrication of these fireworkes prescribed; and now I will set downe the manner how to make all sorts of ballouns and flying faucissons, which are absolutelie the beautifullest parts of fire-works for pleasure, and after them I will describe a braue fireworke for pleasure with the manner how to place, dispose and range euerie peece and part thereof, to make their play in order.





## CHAP. XVII.

### *How to make Girondells or fierie Wheeles.*



Girondell (or as some call it a fierie wheele) is often required in great or little fireworks for pleasure, and therefore I haue thought fit and necessary to set downe their description, as well as of al other parts of fireworks: for according to the application of the Girondels in a Firework, one may iudge of the Enginiers industrie, for being well applied, they  
adorne

adorne very much a fireworke, and being ill applied they spoyle all. And to makethem, you must make wheels of wood as bigge as you pretend to make Girondells, and vnto those wheeles bind fast rockets of a meane bignesse, binding the mouth of one towards the tayle of the other, and so continuing vntill you haue filled your wheele quite round, which done, couer them with paper pasted very curiously about them, that the one taking fire, they take not fire altogether, but the mouth of one shall be left vncouered and ready primed, fit to take fire, the which ending shal giue fire backward to the next, and so one to the other, euery one his turne: there may bee bound fierie Lances to these Girondells either vpright, or neere overthwart, which

which will shew diuersitie of fire the wheele turning: also there may bee added to these wheeles boxes of fire, provided that they be artificially applied in such manner, that they balance the wheele equally, although the proper vse of girondeles, is onely to garnish the angles of a great Fire-work, without much trouble, for that confusiō is too frequent in fire-workes; and therefore it shall be expedient to auoide the multitude of fire-workes too neere compacted together; but placing them as much distant as conueniently may be admitted, by which meanes you shall bee the better able to attaine your designs pretended.



## CHAP. XVIII

*The manner how to make  
Ballouns.*

He ballouns being the perfectest part of all artificiall fire-workes for delight, I thought best to set their description heere apart from the others, to the end that the learners might the better and more easie attain to the knowledge and perfection thereof; and being that I haue already described the mortar, which is represented by the figure A, following, I will onely referre the reader to the second chapter of the first

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first Treatise for warres, where hee  
he shall find sufficient instruction for  
the making of the instrument. But to  
make a Balloune shall be required a  
woodden rowler, which is repre-  
sented by the figure B following;  
this rowler must be of such bignesse  
as you desire to make the inside of  
your balloune; vpon which rowler  
let there bee rowled as many palls  
boards as you shall think sufficient for  
strength being well glued together  
and choake this cartoush at the one  
end, leauing a little hole for a portfire  
as shall follow, and glue it in. This  
portfire shall be made iust like vnto a  
rocket for the ground, but only that  
the composition may be somewhat  
flower; as for the ayre, and to know  
of what length this portfire ought  
to be, it shall not bee amisse to

try a balloune filled with earth; then  
your portfire being well fastned to  
the balloune, place all your serpents  
within it, putting nothing else a-  
mongst them, but onely one or two  
saucissons, to breake the balloune  
on high, when the serpents be all on  
fire, these saucissons must be made  
of the length of your serpents, and  
your serpents may be of the bignes  
of your rockets for the ground be-  
fore prescribed, but not so long,  
and they may bee filled with the  
composition either for the ground,  
or for the ayre: but it is to bee no-  
ted, that they must bee primed  
with the composition for the ayre,  
pressing verie stronglie the priming  
powder into the throat or gorge of  
the serpents, if it bee put in drie;  
but if that weite, then onely with  
I 2 the



the end of a sticke, or else with ones finger put in a little; as for other serpents and the two saucissons shall haue their primings somewhat lon-



ger then the serpents, to the end that all the serpents may be a fire before that the balloune breake. The serpents being not made too long, one may

may put two or three rankes in one balloune, as appears by the figure C, or one ranke of serpents, and over them many Starres; all these things being thus disposed within the cartoush, let it be choaked at the other end; and then prime the ballouns with cotten wicke steeped in gunpowder as the stoupel before spoken of; but this cotten must be well fastened to the end of the port-fire with strong packe thread, which done, charge the balloune in your mortar, as is taught in the 6. chap. of the first Treatise; and you may shoot it when you please. This balloun is represented perfect by the figure D, but if you will fill your ballouns with stars only, another manner of proceeding shall be required; for as you put in your starres into the cartoush; let

there bee powder-duſt mingled amongſt them here and there to giue fire to the ſtarres, and to breake the balloune being vp in the aire. There is alſo another ſort of ballouns to be made, but the expence of making the is ſo exceſſiue, that few or none will be at the coſt, yet the deſcription ſhall now follow. In ſtead of ſerpents made of paper, you may haue them Iron about the bignes of your little finger, and one inch and a halfe of length, or two inches; and neer to the bottome there muſt be a double bottome in the middle whereof there ſhall be a little hole, that one may fill the ſpace between the two bottoms with corned powder, and the reſt is to be filled with a compoſition ſomewhat ſlow, the difference betweene thoſe of Iron, and the former of paper,



per, is that many Iron ones may bee laid in a lesser space; but in stead of a pastbord cartoush, there must bee had a wooden box, made by a Turner, and couered with canuas and glue; the portfire must be made also of Iron like to a little hat, hauing in the bottom two or three little holes to giue fire to the serpents; but for the expence of one of these, there may be made halfe a dozen of the others, nay neere a dozen, wherefore I would wish no man to trouble themselues with this sort, vnlesse it be for the pleasure of some great Prince.

I 4

CHAP.



## CHAP. XIX.

*How to make flying Saucissons.*

The method which must be obserued in making flying saucissons, is most easie, provided that one knoweth already the manner how to make the common sort before prescribed, for the cartoushes are to bee made all alike; onely excepted that those which are for flyers, be somewhat longer then the others, they are to be charged in like maner as the others, but the corned powder being  
put

put in, there must also be a litle powder-dust put after it, and beaten with a mallet, as the rockets for the ground yet let not more then the thicknesse of a finger be of dust-powder, and then choake it almost quite together leauing onely a hole as big as a small goose-quill, to which you shall put a little wet powder-dust for priming. They may be made otherwise, as followeth, which will make a more beautifull shew; first of all, you must charge the cartoushes as the common saucissons, and then choake them as the common leauing onely a little hole to take fire at, or if the hole chance to stop quite vp, open it with a bodkin, but the saucissons being charged and choaked, there must be part of the cartoush left ouer and aboue that which is charged, which  
part



part shall be filled either with powder  
dust, or els with composition of rock-  
ets for the aire beaten w<sup>it</sup> a mallet,  
as before mentioned, I thinke it shall  
be needles to tell you that they ought  
to be couered with chord, being that  
it is sufficiently demonstrated before,  
it is to be noted that the saucissons  
which haue the powder within the  
choaking, doth turne wonderfully  
in the aire, but the other sort which  
haue the composition after the choa-  
king, flye vp like to a rocket, almost  
carrying a great rayle after them, but  
the rayle of the others sheweth but  
very little, they are both sorts repre-  
sented by the figure E, in the 18.  
chapter.

not and the round hole ought to be  


have a little breach to passe through  
 a pecke of waxe **CHAP. XX.** to make  
 be fastned, so that a port-fire may be

*How to make short Gunnes foroyal*  
*the Saucissons.*

**H**AVING already treated suffi-  
 ciently and amply of the fa-  
 brication and making of  
 the Morter, in the imitati-  
 on whereof most easily may bee  
 made Canons to shoote flying Sau-  
 cissons very high in the aire, making  
 them of the one or the other matter  
 or stufte prescribed for the Mor-  
 ter in the second chapter of the first  
 Treatise, but the powder sacke needs  
 not







## CH. A. P. XXI.

*The manner how to dispose and  
build a great or little Fire.  
worke.*



**T**is a custome and  
vsual thing among  
the braue and skil-  
full Painters; to  
teach their appren-  
tises how to draw  
limbs, or members, as the eye, the  
nose, the mouth, the eare, the hand,  
the foot, and afterward the whole  
bodie; and in like manner, the most  
learned

learned and famous Philosophers, beginning their schooles, teach their disciples what is *materia*, *forma*, & *primatio*; and afterward, *totum compositum*; and to imitate them in this Treatise, I haue taught the one after another, all the parties required are necessary for the composing & building of a beautifull fireworke for delight, hauing begun with the rockets for the ayre, afterward the rockets for the ground, the saucissons & rockets for the water, and following the ballons and flying saucissons with all things belonging vnto them; and to auoyd falling into the old prouerbe (*Ex omnibus aliquid, & in toto nihil*: to know something of euery thing, and nothing perfectly) I haue here set downe after all these parts the description and manner how to assemble,

ble, build and dispose any manner of  
artificiall fireworke great or little:  
and to begin, you must first cause to  
be built a scaffold triangular, square,



round, or of such forme and bignes  
as you shall desire to haue your Fire-  
worke, your scaffold being built, dis-  
pose thereupon your statues or fi-  
gures



gures which shall be prepared for it, let them be made of osiers, and covered with paper or canuas, and curiously painted as here is represented in this figure. Mountains, buildings and many statues, all which are to be supposed, onely osiers and paper, or canuas painted, your figures or statues thus disposed vpon your scaffold, round about the flore therof, shall be layed your saucissons, being already fastned to peeces of timber, and to the pillers of your scaffold or raile, shall be fastned your fire lances one right vpward, and the other flat along, each distant, the one from the other about halfe a foot; and vnder the fire lances, let there be nayled a ranke of boxes of fire, which shall be ranged vpon peeces of wood as the saucissons, all your fireworkes be.

being thus disposed, you may place  
in the side which is of least esteeme,  
your partments of rockets made like  
vnto square chests, or long boxes, of  
such bignes and length as shal be re-  
quired to hold those rockets which  
you meane to place in each one; but  
these boxes must haue a false bottom  
full of holes for to passe euery rod of  
euery rocket apart, and hauing fil-  
led let the boxe (which by proper  
name is called a partment) be coue-  
red with a leafe or two of paper pa-  
sted close; but to giue fire to the roc-  
kets, let there be made a hole thorow  
the partment, through it shal passe a  
little peece of stoupel, or cottē wieke  
and giuing fire to that, all the rockets  
within the partment, fly out, and in  
the same manner shal you giue fire  
to all your fierie lances with a stou-  
pel

pel going from the one to the other, and as for your girondeils, you shall giue fire to them with a match, as you desire that they should play, and by this meanes all your fire-workes shall begin to play at once, except those parts which shall bee reserued without priming to be fiered by the hand, as best shall seeine to the artist or enginier, and so the industrious shall not faile to accomplish his designs, obseruing all the rules prescribed; which being at large laid downe I will goe forward to the next chapter, and there shew how to make a most pretious vnguent for all maner of burnings, as well of common fire, as of artificiall fire, if by hazard and mischance arise,



## CHAP. XXII.

*A most pretious vnguent for any  
burning.*



Et no man wonder if  
(having ended this Treatise of fireworkes) I take  
in hand to describe a little part of Chirurgerie; which I confesse to have taken out of a Treatise written by Thyboure, a Chirurgion of Loraine, and having made experience of this vnguent diuerse times as well for burnings, as that for other accidents, I may say with boldnes & truth, that there was neuer the

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like secret of this kind left to posteritie, specially against hurts come by fire, and which leaues lesse scarres after the healing of the places wounded, and therefore I haue set downe the very words which *Thybourel* hath written in the last chapter of his 4th. booke, intituled *Recueil de plusieurs machines militaires.*

Take fresh hogges grease or lard, as much as you please, and boyle it, taking off the skim vntill there arise no more skim; then set the lard three or foure nights in the ayre abroad, after which it must be washed in running water, to take away the saltish nature, and also to clense it white, then melt it, and keepe it for your vse. Bacon may serue in steat of lard.

Other

## Otherwise

The white of an egge or fresh butter  
being mingled together and well beaten  
to an oyle are excellent.

## Another sort most excellent.

Take a stone of unslacked lime (or o-  
therwise called quicke lime) and let it dis-  
solve in cleere water, and when the wa-  
ter is settled, powre it gently out from the  
lime through a linnen cloth; then put as  
much fallat oyle as you take water toge-  
ther, and beating it all to an oyle, you shal  
have a most excellent unguent for all  
kind of burnings, neither of these un-  
guents bane any scarre, but are precious  
remedies for the afflicted.



We haue seene Impostures<sup>r</sup> couer sores with this water alone, but obseruing superstitious ceremonies, saying vaine prayers, but we assure the posteritie, that the water onely is sufficient to beale wounds and scres, onely washing them with it, and couering them with a linnen cloath wet in the same water, without any superstition, it doth modifie and percute, by which it doth suppl nature, and doth beale sores better then our ordinary vnguent.

Thus may you see how this braue Chirurgion that set forth to the face of the world the perfection of this vnguent (which cannot be sufficient-praised) confirming by his own confession, that the Chirurgions do not vse such good remedies in their shops and ordinarie operations; wherefore I haue set downe his owne words, that no man may esteerne mee inuen-

inuenter of Calumnies, against the  
 practitioners of Chirurgery, nor any  
 others, as many now adayes seemes  
 to write with serpents tongues, stin-  
 ging vertue on euery side, against  
 who viperous venoms patience is the  
 only anedote, leauing them to sweate,  
 vexed, and torment themselves in their  
 insatiable rage; and to end my dis-  
 course touching the perfection of  
 this vnguent, I will assure all these  
 who shall haue neede and make vse  
 thereof, that they shall find in opera-  
 tion what I haue here set downe in  
 description.

R. 4



*A Treatise of practicall Geometrie.*

**T**O satisfie diuers of my friends and yeeld to their desires (whose treaties haue bin such powerfull commands to me, that I haue beene constrained to lay aside and forsake my own proper will and follow theirs, I haue set forth this little Treatise of practicall Geometric to the view and cenlure of the world, which I acknowledge to be vnworthy of so many singular and industrious wits, as yearly spring vp in this Iland, and the adiacents there.



hereunto, notwithstanding I haue  
 giuen way to their requests for their  
 priuat contentment, and to assure the  
 world that I haue nothing, no not  
 my owne will proper to my selfe, but  
 that I will follow as neere as possible  
 I may the precepts and documents of  
 that ancient, wise, and diuine Philo-  
 sopher Plato, who saith, *Non nobis*  
*natis sumus, sed patriæ & amicis*; we are  
 not borne for our selues, but for the  
 seruice of our countrey and friends:  
 then for the satisfaction of my friends  
 and seruice of those who will accept  
 these my labours, I haue cleere and  
 in few words set downe the manner  
 how anie man (who hath neuer so  
 little studied Geometrie) may take a-  
 ny distance, or heighth, depth, or  
 breadth with two little stickes, yea  
 euen strawes, being laied a crosse, al-  
 so

so I have set downe a method how  
 to take any kind of height, distance  
 or depth, with the Sector without a-  
 ny arithmetike or rule thereof: and  
 also by the *sines tangents* and *secants*,  
 the whole being very portable,  
 to refresh the memorie, & to streng-  
 then and augment the knowledge  
 of those who (for want of practice)  
 have not the perfect vse of those in-  
 struments: then first of all I will set  
 downe the manner how to accomo-  
 date and dispose the sticks, twigges, or  
 strawes for the measuring of any di-  
 stance.



*The method how to make the  
Crosse.*

**H**Aving two stickes, the one  
long, and the other some  
what short as are represen-  
ted in the figure following  
by C F, and D E, then marke vpon  
the sticke C F, points the one distant  
from the other precisely, halfe the  
length of D E, and let there be a hole  
made through the sticke D E, so that  
it may slide vpon C F, from end to  
end, and you shall know the two  
parts of the crosse by these names,  
the



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the longest part CF, shall be called the index, and the shortest DE, the crosse. Now if you haue any height to take, then fasten to one end of the crosse, as to D, a perpendicular or plummet, and for the more easie and iust operation, you should haue a foot to support the crosse; the instrument being thus prepared, you may measure with great facility either height, breadth, or depth, as followeth.

What height as are repicled  
 ed in the figure following  
 of CF, and DE, then make vpon  
 the thicke CF, point the one distant  
 from the other precisely; halfe the  
 of DE, and let there be a hole  
 made through the thicke DE, so that  
 may slide vpon CF, from end to  
 end, and you shall know the two  
 parts of the crosse by these names,  
 the

141  
**PROPOSITION I.**

*How to take a height accessible.*



Et it be proposed to take  
the height of the To-  
wer A B, to the base or  
foot whereof one may  
easily approach; dispose the crosse  
of your instrument in such sort that  
D C E be of equall distance there  
one from the other; as thus, settle  
your crosse vpon the first point of  
the index; then setting the instrument  
to your eye, goe either neerer, or re-  
tire farther from the object you de-  
fire

first to measure vntill you see A the highest part thereof by the two extremities of the crosse C D, (the index being paralld to the earth) which will happen in the point C, and not else-where: that being measured, will be alwayes the iust height of the Tower required, onelic obserue that you must alwayes adde to the distance betwene you and the Tower the length of the foot, which supporteth your instrument, and so you shall haue preciselic the height required: for scarce euer will it happen, that the instrument may be placed leuell with the base or foote of the height required, but if that should chance to be, then the extremite of the index C would arriue in the point G and so nothing to be added, but onelic measure the distance



betweene G and B, and that would  
be the iust height required; but if it  
chance that you may not plant the  
instrument in the point G, by reason



of some inconveniencies which may  
happen retire further backe, and put  
forward the crosse to the second  
point of the index, and then accord  
your

your visuale lines to see the point A  
(the index alwaies being paralel to  
the ground) which then will happen  
twice the height required, distant  
from the foot thereof: but if it hap-  
pen that going backe you ascend a  
nic little mountaine, or descend into  
any little valley, you are then to ob-  
serue some point in the wall of the  
Tower, which the index shall direct  
you to by the line visuel, & adde on-  
lie the height thereof vnto halfe the  
distance twixt you and the Tower,  
and that shall be the height requi-  
red most exactlie: and thus you shall  
neuer faile in your operations.

you doine some inuentiones which may  
happen to the first and the second  
the crosse to the second  
point of the index, and then second  
you

then let a mark there in D, and go  
ing back towards the first mark



## PROPOSITION. II.

*How to take a height inaccessible,  
or one height upon another  
height.*

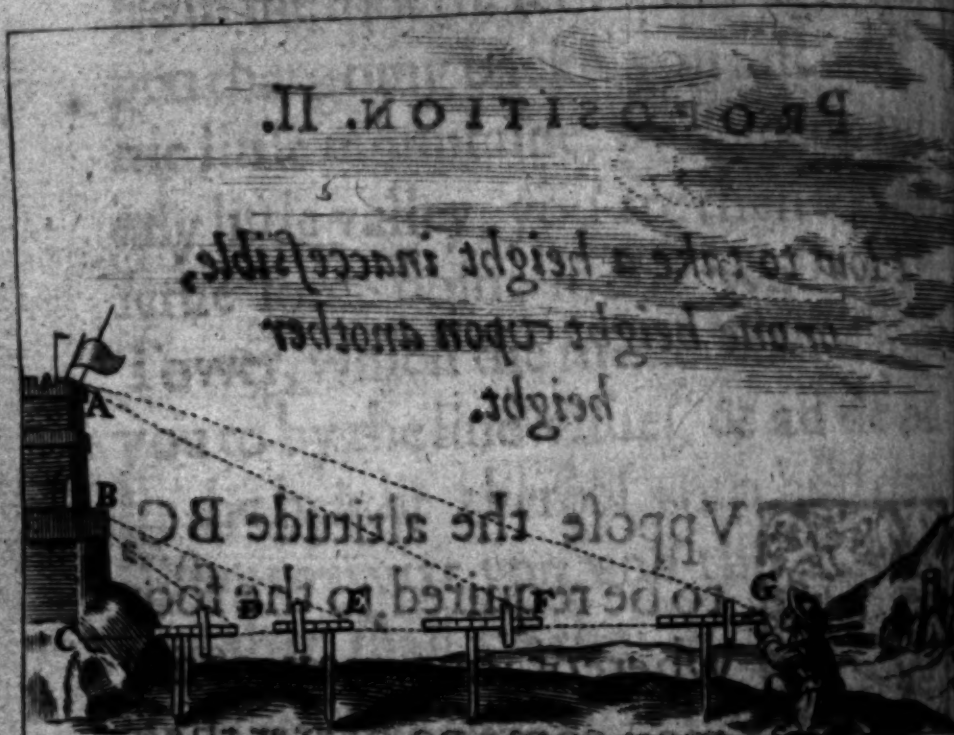


Suppose the altitude BC,  
to be required, to the foot  
whereof one may come  
may come no nearer then

to the point D, then at the point D,  
accord your visuall line to B and C,  
the index being alwaies leuell with  
the ground and the crosse fixed upon  
the first marks or point of the index,  
L then



then set a marke there in D, and going backe towards F, as farre as E, and put forward the crosse to the second point of the index, and then direct



your lines visuel againe in B and in G which will arrive in E, and not elsewhere, then measure the distance betweene D E, which will be the al-

titude

altitude precisely required; But if you  
 desire the height of the Tower, and  
 the mountain level with the  
 foot of your instrument, then  
 you must add the length of the  
 staffe, which supporteth it as in for-  
 mer observations. And to have the  
 altitude  $AB$  vpon the top of  $BC$ ,  
 you must take two other obseruati-  
 ons in  $FG$  as before, setting your in-  
 strument in  $F$ , the crosse being fix-  
 ed vpon the second point of the in-  
 dex, and direct your visuall lines in  
 $A$  and in  $C$ , and then set vp a mark in  
 $F$ , and goe backe, putting forward  
 the crosse to the third point of the  
 index, and direct your visuall lines  
 againe in  $A$  and in  $C$ , which will  
 happen in  $G$ , and not elsewhere,  
 then measure the distance betweene  
 $FG$ , which shall bee equall to the

altitude of the Tower  $AC$  and  
 having taken already the altitude  
 $BC$ , you may yet easily subtract  
 the little altitude  $BC$  from the  
 greater Altitude  $AC$ , and then will  
 rest the altitude  $AB$  which is re-  
 quired. And to have

altitude  $A$  upon the top of  $B$ .  
 you must take two other observa-  
 tions in  $E$  as before, setting your in-  
 strument in  $E$ , the crosse being fix-  
 ed upon the second point of the in-  
 dex, and direct your vidual lines in  
 $A$  and in  $C$ , and then set up a mark in  
 $E$  and goe backe, putting forward  
 the crosse to the third point of the  
 index, and direct your vidual lines  
 againe in  $A$  and in  $C$ , which will  
 happen in  $E$ , and not elsewhere,  
 then measure the distance between  
 $E$  and  $E$ , which shall be equal to the

PROP.



## PROP. III.

*How to take any distance vpon a  
place accessible or inaccessible.*

**I**F it were proposed  
to take the distance  
A B, and that the  
place were accessi-  
ble onlie in the  
middle vpon the  
line C F, then dispose your instru-  
ment as before the crosse placed vp-  
on the first point of the index; and  
going forward or backward vpon  
the line C F, direct your sight lines  
in A and in B by the two extremiti-  
es of the crosse, the end of the index

resting against your cie, then measure  
the distance betweene you and the  
point F, and that shall be iust half the  
distance required betweene A B, but



if the place be inaccessible, so that  
you may not approach nearer then the  
point D, put forward the crosse to  
the second point of the index, & then  
direct

direct your visuel lines to AB, and  
 leaue a marke at D, and put forward  
 the crosse one point more, and going  
 backe vpon the line D E, vntill you  
 may direct your visuel lines by the  
 extremities of the crosse againe in  
 A and B, then measure the distance  
 between D E, and that will be halfe  
 the distance betweene AB, and so  
 may you operate going backe, and  
 putting forward the crosse.

**PROP.**

**L**



thus,  $EA$  or simil buliv moy scrib

~~the distance between the two points~~

backe upon the line  $D$ , and you

may find your distance by the

PROPOSITION IV.

Another manner how to take

distance inaccessible.

the distance between  $A$  and  $B$ , and to

Suppose the distance  $AB$  to be

taken, and that  $B$  is the nearest

place that may be required, then

there must be set a marke, and with-

drawing backward in a straight line

towards  $C$ , and there againe plant

another marke at  $C$ , then going right

towards one side, as towards  $E$ ,

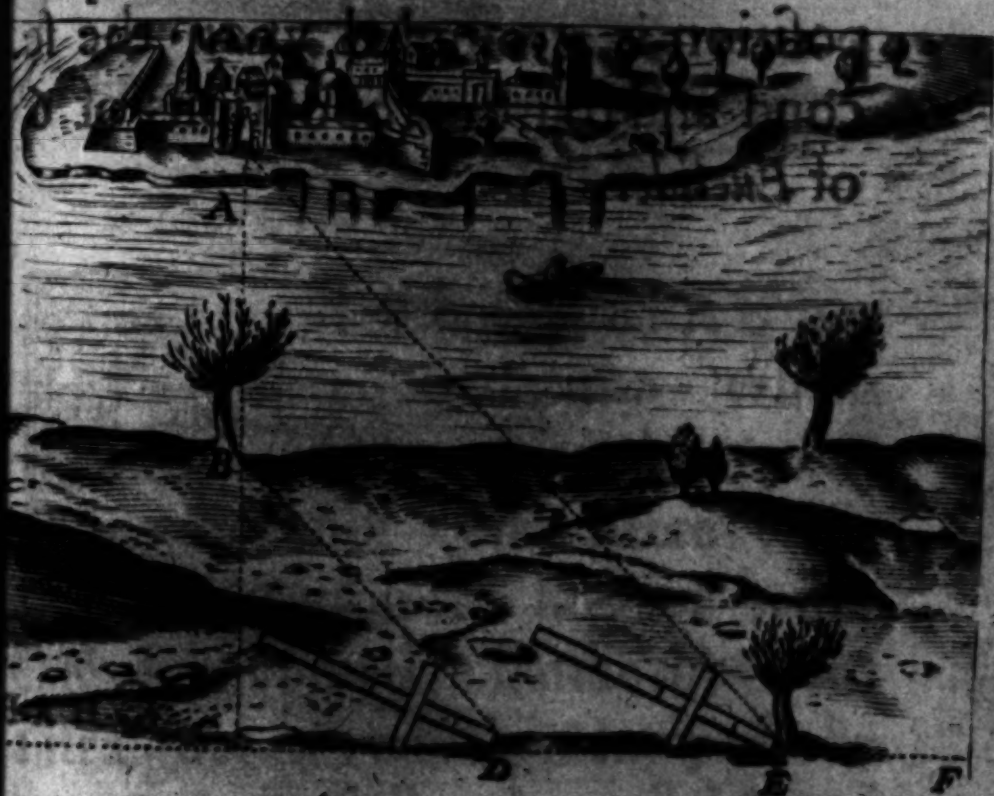
counting your places equall to the

number which you have already

found  $B$  and  $C$ , and there direct

your

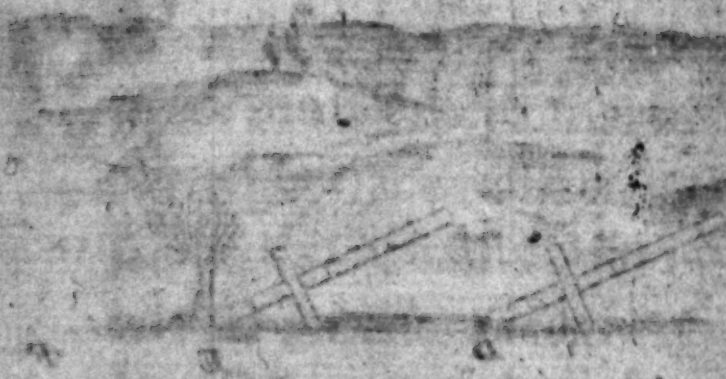
your visuel lines in BGC, as in this figure at D, leaving there a mark, goe straight along towards F, not moving the crosse of your instrument,



and going along make trial where your visuel lines may be directed again in A and in C, which will be in the point E, and not else-where, then

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then leaue there a marke, and  
measure the distance betweene D  
E, and that shall bee the distance  
which you require, which is A  
B, the demonstration of this pro-  
position is grounded vpon the se-  
cond and fourth propositions of 6  
of *Euclide*.



CHAP

and going along make trial where  
your viuel lines may be directed a-  
gain in A and in C, which will be in  
the point E, and not else-where,  
then



And the distance of the line AB  
which you may direct your  
visual lines to A and B which will

PROP. V.

*How to take a distance onely vpon  
a line parallell to it.*



Et the distance AB bee  
required, the which  
may neither bee seene,  
nor come neere vnto,  
but onelie vpon the line or banke  
CK, then vpon that banke draw out  
a straight line with markes, as the  
line CK, paralell to the wall AB, and  
set a marke in K, then goe backe to-  
wards D and direct your visuel lines  
in B and in K, by the extremities of  
the crosse GH then leauing the crosse  
in

llsup

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in the same state and a marke at D,  
withdraw your selfe further back to-  
wards C, vntill you may direct your  
visuel lines to A and K, which will



happen in C, and not elsewhere, and  
leau there another marke then mea-  
sure the distance betweene C D, and  
the same shall bee the breach A B, e-  
quall

quall to  $\angle D$ , and the demonstration  
of this proposition is grounded in  
the 29. and 33. propositions of the  
1. of *Euclide*.

then from the point D, take the



and both by your scrib, and gained  
gained by **P. R. O. P. V. I. N. O. R. A. M. O. R.**

How to take the depth of a well

same angle upon the plain; which

**I**n take the depth of a Valley, there is some what more difficult then in the former operations, because there are more observations to be made, and to begin you must from the point B observe in some place op.



opposite make levelly with the horizon as *A*, the level whereof you may easily take at this instrument as is taught in the second proposition by the helpe of the plumb: then from the point *B*, take the distance *BC*, as in the fifth proposition, or the mecanike, which being done, direct your visuel lines from *B* to *A*, and to *C*, and leaving the instrument in same state, turning your selfe about, frame the same angle vpon the plaine, which will be *EBH*, then place a mark on the lines *BF* and *BH*, and vpon the line *BH*, count as many paces or fathoms as you shall have found betwene *B* and *C*, and at the end of your paces, place a mark, which will bee *E*, this being

being done, dispose your instruments  
to make a right angle, placing the  
crosse vpon the first point of the in-  
dex, for the crosse maketh alwaies a



right angle when the crosse is vpon  
the first point. The instrument being  
thus disposed, walke vpon the line  
B F, vntill you may direct your visu-  
ell

all lines (by the extremities of the  
 crosse) to B. and E; or els to F. E,  
 which will happen in D, and no  
 where els; then measure the line D  
 E, and it will be equall to the depth  
 required G C, the demonstration of  
 this proposition is grounded in the  
 26, of the 1. of *Euclide*, or vpon the  
 equalite of the two triangles B G C  
 and B D E, which are both equall  
 and equall angles. Although this o-  
 peration be somewhat more obscure  
 then the others, yet I thinke that it  
 is sufficiently explained, and therefore  
 I will goe forward to the vse of the  
 sector.

noqy aione the newe angle upon  
 gine instrument. The instrument being  
 set, walke vpon the line  
 - ally you may direct your view  
 ll





# PROP. IX.

*The manner how to take either distance or altitude with the Sector.*



Suppose the altitude A D were to be taken to the foot whereof you may approach open the Sector 45 adding to it the sights then going forward or backward vpon the line DI, vntill you may see the highest part of the altitude A, through the two vpper sights, the inferior branch of the Sector, being paralell to the earth or  
M — hori.



length of the foot of the sector, you will find, that it will be height of B D, which doth accomplish the altitude of the Tower. But to take a distance in any plaine, as in the figure precedent, the same operation may be vsed, except onely the two branches of the sector shall be turned parallel to the horison or ground, having first made a right angle at the point G, or you may operate otherwise; first of all prolong a straight line as E G H of what length you please, then open your sector to a right angle, and set it the point G, so that you may see through two sights the point E, and where the line visuel of the other two sights strikes along, set vp a merke as in I, then goe towards it, and at your pleasure in the same line, set your sector opening it,



so that you may see the point E and G, and keeping your instrument at the same width, & in the same place place, only turne it to the other side, so that you may see the point G, thow the sights which before saw E, and where the other visuall line shall cut the first line EGH, set a marke which will be in H precisely, and that shall be the distance required GE, the demonstration of this proposition is grounded vpon the 4. and 26. of the 1. of *Euclide*.

**PROP:**

## PROP. X.

*How to take any distance or altitude  
inaccessible with the Sector.*

**T**O obtaine the altitude  
A B, you must first take  
the distance B C. as is  
taught by the 9. Propo-  
sition precedent, and  
knowing the distance B C, which I  
suppose to be 100 fathom, set in the  
point C your Sector, and direct your  
visuell line through the two vpper  
lights to the top of the altitude A, and  
let the branch of the Sector be paralel  
with the ground, then leaving your

M 3

instru-

instrument at the same width, let fall  
a perpendicular line vpon the line of  
the Sector divided into equall parts,  
passing by the 100 number of the infe-



rior branch noted D, and note what  
nūber the perpendicular doth cut vpon  
on the ypper branch of the Sector no-  
ted H, which I suppose here to be



the 150 part or number, and then set the two points of a paire of compasses vpon the two numbers, to wit, the one point vpon 100, and the other point vpon 150. of the equall parties, then transport the points of the compasse all along one branch of the Sector vpon the line of equall parties, and the two points shall denote as many parties vpon the line of the Sector as the Towre doth containe fathoms in altitude, adding the length of the foote which supporteth the Sector, the demonstration of this Proposition is grounded vpon the 4. Proposition of the 6. of *Euclide*.

**M 4 PROP.**

*OF SINES, SECANTS, AND TANGENTS.*

## PROP. XI.

*Of Sines, Secants, and Tangents.*



Because the most noble, most artificiall, and most certaine way of taking of Altitudes, Distances, or other Dimentions, is by Sines, Secants, or Tangents, I haue let downe their operations in such Propositions as are visuall in this subiect at the end of this Treatise of Practicall Geometrie, and before I enter on the method of operation, it is necessary to define what the said Sines, Secants, & Tangents are.

1. A right Sine is halfe the Subtence of the double Arke.

A Subtence, sometimes called a Cord, is a right line drawne from any part of the Circumference of a Circle, vnto any other part of the same Circumference, so the right line DE is the Subtence or Cord of the Arke DGH halfe of which is DF, the Sine of the Arke DG; and so is MN the Subtence of the Circumference or Arke MGN, halfe of it is MI, which is the Sine of the Arke MG; now the Arke MG is halfe of the Arke MGN, and MI is halfe of the Subtence of that double Arke, viz. MGN; hence it is according to the definition aforesaid, that the Sine of any Arke is halfe the Subtence of the double Arke; by the same reason OT is the Sine of the Arke BO and MS is the Sine of the Arke BOM and so of others.

Note that the Sine of any Arke lesse then





to the greater; and therefore halfe of the Subtence which is the Sine shall be common vnto halfe the lesser Segment and also vnto halfe of the greater; which two halfes put together make a Semicircle; and therefore the one is the Complement of the other.

21 Note further that the totall Sine, the Sine of 90, or the Radius, is nothing else but the Semidiameter of any Circle, viz.  $CB$ , or  $CG$ .

If a line be drawne touch a Circle, it is called a Tangent, (*a tango*) as the line  $AB$  toucheth the Circumference of the Circle in  $B$ , and so  $AB$  is called a Tangent line, and is situated on the Terme of the Radius  $CB$ , and perpendicular thereto, by the 18 Proposition of the 3. of *Euclid*.

2. The Secant of an Arke is a line contained betweene the Center and the  
the

the line Tangent, so that it passe by the given Arke, so if  $BO$  be a given Arke,  $CQ$  is the Secant thereof, and if  $BM$  be a given Arke, then is  $QR$  the Secant thereof.

3. The Tangent of an Arke is a line contained betweene the tearme of the Secant, and the touch point, so  $BQ$  is the Tangent of the Arke  $BO$ , and  $BR$  is the Tangent of the Arke  $BM$ , &c.

**PROP.**





PROPOSITION. XII.

*How to take any altitude or distance*

*by the Sines, Tangents and*

*Secants.*

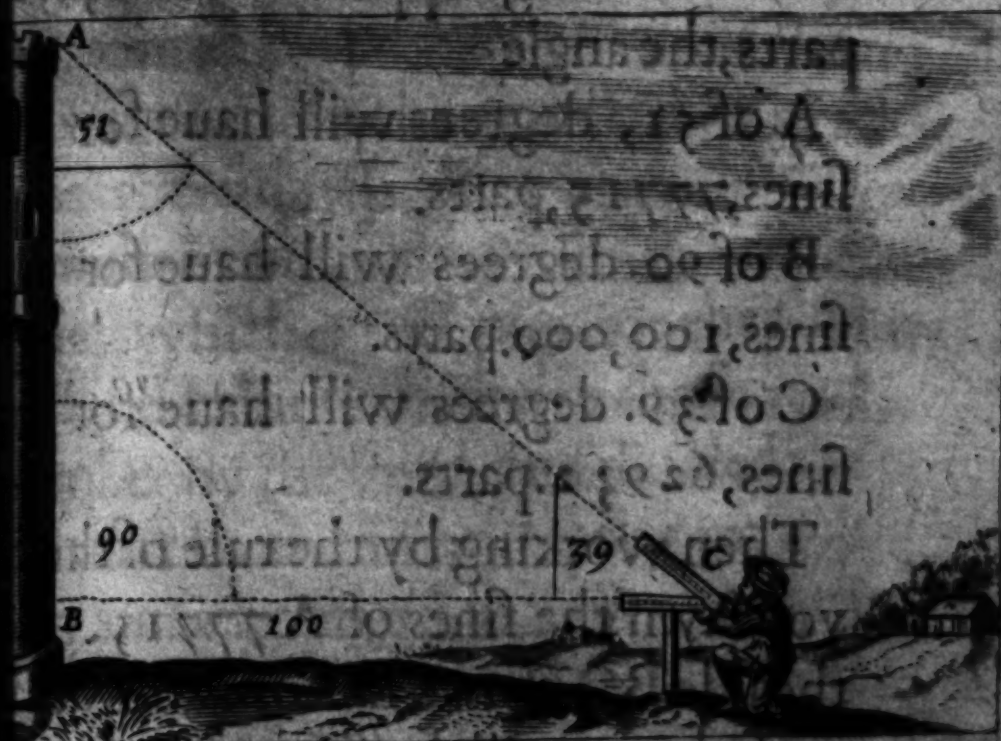


First of all is to bee noted that in all triangles as each side is the one to the other, even so each sine will bee one

to the other: that is to say, each sine of a triangle equilaterall shall bee equall amongst themselves, or one sine, as the sides of that triangle are all equall, and

and the line of a Scalene triangle shall be all inequall and different amongst themselves, as the three sides of the triangle are different one from another. Now for operation let it be proposed to take the Altitude  $AB$ , to the base or foundation whereof you may well approach, then there begin to measure your paces or fathoms from the base  $B$  to some place in the plaine which I suppose to be  $C$ , and there set your instrument either Sector, Graphometer, or any other with which you may take the degrees of an angle, and in the point  $C$ , take that angle which is found to be of 39. degrees, & the angle  $B$  is already knowne to be of 90. degrees, the Tower standing upright: now rests to know the degrees of the angle  $A$ , which to obtaine take 90. to 39. and it maketh 129. which

which you must subtract from 180.  
and then will rest 51. which the an-  
gle A containeth, and so the three an-  
gles are knowne, and the one side of



the triangle BC, is also knownd to  
containe as I here suppose a hundred  
athom, and to know the quantity of  
the other two sides AB and AC, by  
the



the fines, tangents, or secants, you must seeke in a table of fines the fines of each angle which will be found as followeth, the sine totale, or the demi-diameter being supposed of 100,000 parts, the angle.

A of 51, degrees will haue for his fines, 77715, parts.

B of 90. degrees will haue for his fines, 100,000. parts.

C of 39. degrees will haue for his fines, 62932. parts.

Then working by the rule of three you say if the fines of A 77715. giue the side BC of 100 fathoms, how many fathoms will the fines of C, 62932. for the side AB, and dispose your rule of three as followeth. If 77715—  
100—62932. And hauing multiplied the second number by the third or the third by the second, and di-  
de

led the product by the first number,  
 and the quotient of the diuision will  
 be for the side AB 80 fathoms, 70 in-  
 ches, 4 lines and  $\frac{1}{2}$  parts of a line And  
 to find out the side AC, you must o-  
 perate in the same manner by the rule  
 of three, & say if the sine A of 79715  
 giues the side BC of 100 fathoms,  
 how many fathoms will the sine B  
 giue, which is 100,000. for the side  
 AC, and hauing multiplied the second  
 number by the third, and diuided the  
 product by the first, the quotient will  
 be 128 fathoms, 48 inches, 7 lines, &  
 $\frac{34875}{77715}$  part of a line, which is almost  
 one line for the side AC, and thus  
 may you know any kind of distance  
 with great facilitie, onely knowing  
 the angles and one side.

PROP.



# PROP. XIII.

*How to take any altitude or distance inaccessible by the sines.*



Et the altitude A C be  
proposed to be taken, and  
the neereſt comming to  
it is B, then in that point  
B, take the angle A B C, as in the  
chapter before, which is of 61. de-  
grees, then aſſemble 61. with 90. the  
right angle opposite and the whole is  
151, which you muſt ſubſtract from  
180, and then will reſt 29 for the  
angle A, and ſo the three angles of the  
trian-



triangle are known, but neither side;  
and therefore to know one of the  
sides, that we may operate by the  
sines, tangents and secants, retir:



further backe or aside to D, and mea-  
sure your paces or fathoms from B to  
D, which I suppose here to bee 300.  
paces, and in the point D, take the

N

an-

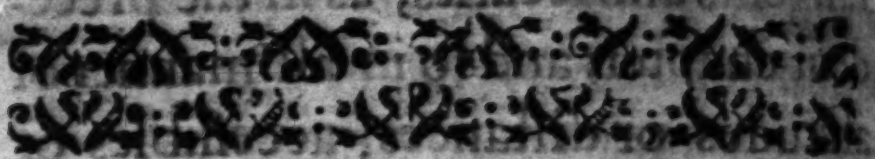
angle  $ADB$ , which is 37. degrees, and then may know that the angle exterior  $ABD$ , is of a hundred and nineteene degrees, for it is equal to the two interior angles  $ABC$  and  $BAC$  by the 32. proposition of the 1. of *Euclide*, or otherwise it is the complement of the halfe circle, of which the angle interior  $ABC$  of 61 degrees is taken out, now you haue the knowledge of two angles  $ADB$ , and  $DAB$ , the which being ioyned, subtract them from 180. and then the third angle will remaine  $DAB$ , then shal you know the three angles of the triangle  $ABD$ , and one of the sides by which you may come to the knowlege of the side  $AB$  of the first triangle  $ABC$  by the sine, and by the knowledge of the side  $AB$ , you may also know the side  $AC$ , by the sines.

tangents and secants, as in the prece-  
dent chapter: and so in all manner of  
altitudes or distances, accessibles or  
inaccessibles, and it is to bee noted,  
that one is not bound to wright back-  
ward, taking the second obseruati-  
on in D, but at the pleasure of the  
workeman to make choise of the fai-  
rest place in the field, so I thinke no  
difficulty shal be found in these works

N 2

The





*The manner how to take the plane  
of a towne, or any place out  
of musket-shot.*



Suppose you were to take  
the plane  $ABCDE$ ; first,  
having considered that  
the situation of the  
plane hath a crooked arke  $BAF$ ; those  
two lines must be supposed straight  
as  $EQ$  and  $BP$ , making an obtuse  
angle at the point  $A$ , and being farre  
off from this plane in the point  $P$ ,  
consider that the lines  $PB$  and  $QE$ ,  
make but one angle in the point  $A$ , the  
leaving a marke at  $P$ , withdraw from  
thence into some other place of field  
where

where your eye may rightly meet  
with the line  $AE$ , which will happen  
in  $Q$  where you must set another mark  
now consider that if a line be drawne  
from  $Q$  to  $P$ , it will forme a triangle  
 $APQ$ , whereof you may know two  
angles,  $PQA$  and  $APQ$  which being  
done with your instrument, and you  
find the angle  $APQ$  to bee of 45. de-  
grees, and  $PAQ$  of 34. degrees, then  
adde 45. to 34. and comineth in the  
whole 79. which you must subtract  
from 180 degrees, and there will rest  
101 for the third angle  $PAQ$  by the  
32. proposition, lib. 1. of *Euclide*, and  
the angle  $EAB$  is equall to the angle  
 $PAQ$  by the 15. proposition 1. then  
lets conclude that we haue the an-  
gle  $BAE$  of 101 degrees, which was  
unknowne, then shall it be necessary  
in the place noted  $B$ , to know how

the side CD is situated in respect of  
the parts of the world, and with a  
declinatorie we shall find it to be sea-  
red North, West & Southeast, which



shall serue vs for the knowledge of  
all the rest: and in the former man-  
ner may be taken all the other angles  
of the plane proposed, and to haue

the



the distance of each side of the plane,  
you must measure one onely as be-  
fore taught, which I suppose it shall  
be  $BC$ , which shall bee found to bee  
100 fathoms, and hauing found a side  
homologe to it or like to it, and di-  
uided into an hundred parts equally,  
it shall serue for a scale to measure all  
therest by.



N<sup>o</sup> 4

CHAP.



CHAP. I. Of the  
*A treaty of fortifications as well  
 regularly as irregularly,*



It is not my intention to treat here of all manner of fortifications, but only of those which by the generall and common opinions are held and approved to bee the best for the defence and conservation of deserving places; and to begin this Treatise, I will set downe certaine rules which are

are now held for maxims of the best fortifications.

Let the flanked angle be open 90. degrees, or the neereſt to 90. that may be it is the angle A in the next triangular figure.

Let the flanking angle be not above 150. degrees open, but the leſſer, ſhall alwayes be the beſt, this angle is BL C in the ſame figure.

Let not the line of defence be longer then muſket ſhot, which is 100, or 110 fathom, it is CK or BI in the ſame figure.

The largeſt necke or gorge of a baſtion or bulwarke is alwayes the beſt and the longeſt flanke lines, ſpecially if eares be to be built vpon them, C N or M P are noſe lines.

Now ſhal follow the denomi-  
nations



tions of fortifications for the better  
intelligence of the better treating of  
them.



## CH AP. II.

### *Denominations of the parties of Fortifications.*



Flanked angle is the  
point of a bulwarke in  
the figure following. it  
is the angle SBN.

A flanking angle is BLC, which is  
made by two lines of defence meet-  
ing in the point L.

A line of defence is the distance  
from

from the flanke to the angle flanked,  
as here B I, or C K,

The flanke is K or L

The line of the flanke is KN or IM

The curtine is the strait line drawne  
from one flanke to the other, as here  
KI.

The shoulder of a bulwarke is N  
or M,

The pane of a bulwarke is B N

The care is alwayes built ypon the  
line of the flanke, as in the second fi-  
gure following.

The capital or chief line is B I or F C

Bastion or bulwarke is a picce con-  
tained within two lines, two panes,  
and two flankes.

The necke or gorge of a bastion is  
the distance betweene the two flankes  
for the entrie into the bastion.

A rampard is the earth raised against  
the

the wall in the inside to strengthen it  
against Canon shot.

The parapet is the elevation above  
the firing of the wall.

The counter escarp is the exterior  
brim of the towne ditch.

A halfe moone is a peece loose from  
the towne raised of earth, and inuol-  
ned with a ditch to hinder the assault  
of the enemies, it is sometimes made  
in forme triangular, but sometimes  
oblong as occasion is, now shall fol-  
low the Treatise of the regular fort,  
and first of all the triangular.

The cap or bulwark is a piece con-  
tained within two lines, two banes,  
and two flanks.

The neck or gorge of a bastion is  
the distance between the two flanks  
for the entrance into the bastion.

A rampart is the earth raised against  
the



### CHAP. III.

#### *How to build a triangular Fort.*



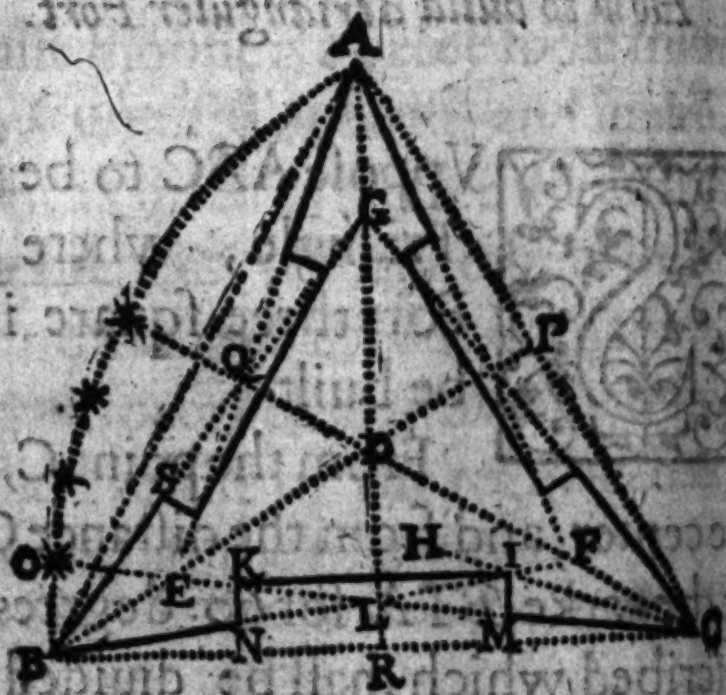
Suppose  $ABC$  to be the Triangle, where in a Fort three square is to be built.

From the point  $C$ , as the center, and from the distance  $CB$ , let the arke  $CTA$  for  $60$ . degrees be described, which shall be divided into two equall parts at the point  $T$ .

And againe, the arke  $BT$  into foure other equall parts, and  $OB$  shall bee an arke of  $7\frac{1}{2}$  degrees, by vvhich draw the line  $CO$ , and it shall forme the diminished

minished angle OCB of  $7\frac{1}{2}$  degrees.

Then divide each side of the triangle in two equall parts by the points  $QPR$ , and draw the strait lines



Capitall line which shal be transported into  $C$  and  $A$ , then draw the straight lines  $BF$ ,  $FA$ ,  $CG$ , and  $AE$ , which shal forme the diminished angles, and become lines of defence.

And to find the point for the flanke diuide the angle  $QCE$  in two equall parts by the straight lines  $CH$ , which teacheth vs the point  $I$ , for the flanke and then take the distance  $FI$ , and carry it to  $EK$ , and the point  $K$  shal be another flanke, then draw the lines of the flankes  $KN$  and  $IM$  perpendicularly to the courtine  $KI$ , which is drawn from the flanke  $K$  to the flank  $I$ , and the same vpon the two other sides, and you shall haue the triangular fort perfect.

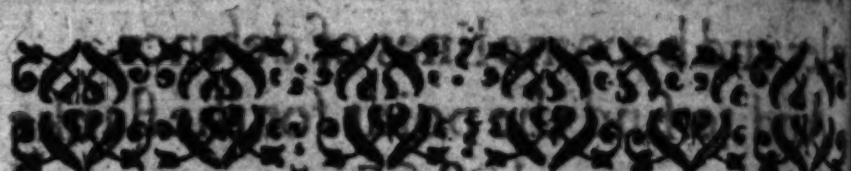
The flanked angle is of 45. degrees, and the flanking angle is 165. degrees

open



open, which is somewhat farre from  
the best maximes of fortifications.

EA and AF, OG, and AE,  
which shall forme the diminished an-



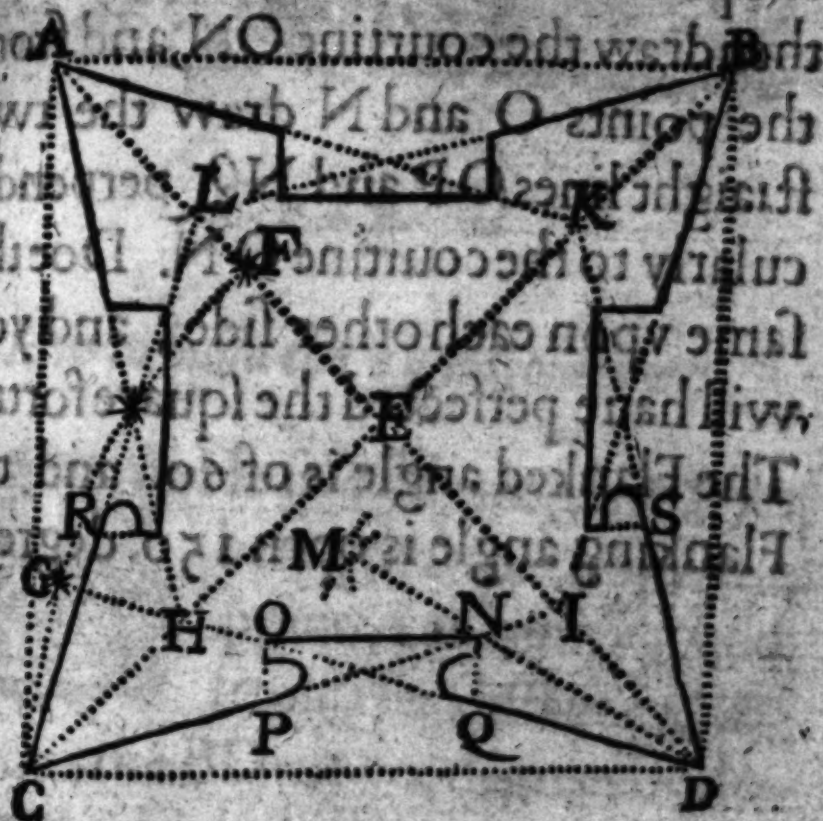
CHAP. IV.  
How to build a Square Fort.

Let the square ABCD be  
in which you desire to  
build the Fort, draw the  
two diagonales AD, CB,  
which cut E the center of the Fort  
from the point D as center, and from  
the distance DC, let the arke CGF be  
drawne, which shall be divided in  
three equall parts, and from the point  
G draw the straightline GD, which  
formeth



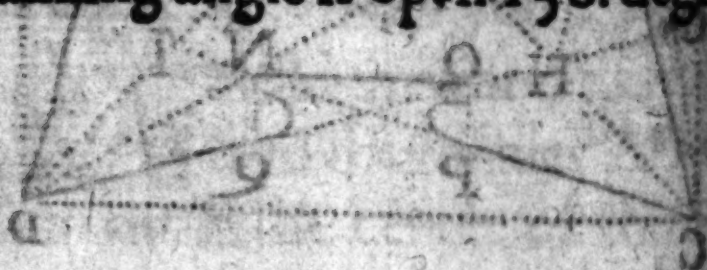
Et the square ABCD be  
in which you desire to  
build the Fort, draw the  
two diagonales AD, CB,  
which cut E the center of the Fort  
from the point D as center, and from  
the distance DC, let the arke CGF be  
drawne, which shall be divided in  
three equall parts, and from the point  
G draw the straightline GD, which  
formeth

formeth the diminished angle GDC  
of 15. degrees; and the intersection of  
the line GD in H doth shew the line  
apitoll CH, which shall be transpor-



ed into I K L, and then draw the  
straight lines CI. DH and their fel-  
lowes, and to find the point for the  
Flanke, divide the angle FDG in two  
equall

equall parts by the line  $DM$ , which cutting the line  $CI$  doth shew vs the point  $N$  for the Flanke, then take the distance  $IN$ , and beare it to  $HO$ , and the point  $O$  shall be another Flanke, then draw the courtine  $ON$ , and from the points  $O$  and  $N$  draw the two straight lines  $OP$  and  $NQ$  perpendicularly to the courtine  $ON$ . Doe the same vpon each other side, and you will haue perfected the square fortres. The Flanked angle is of  $60$ . and the Flanking angle is open  $150$ . degrees.



and then draw the straight lines  $CI$ ,  $DM$  and their intersection point  $M$ , and to find the point for the Flanke, divide the angle  $FDG$  in two equal parts.



must be transported to the other lines



CHAP. V.

*How to build the Pantagone Fort.*

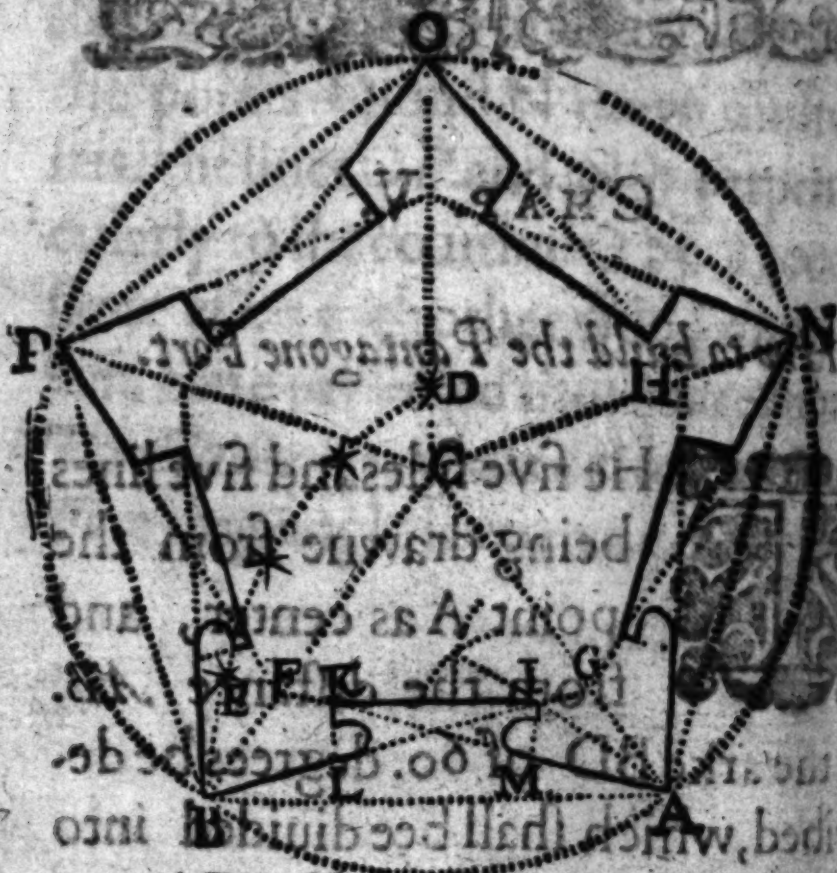


He five sides and five lines  
being drawne from the  
point A as center, and  
from the distance AB.

Let the arke BD of 60. degrees be de-  
scribed, which shall bee diuided into  
four equal parts, of which BE is one  
and from the point E, draw the right  
line AE, which cutting the line BC  
at the point F, doth giue the part EF  
for the capitall line; which distance

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must be transported to the other lines  
AG, &c. then from the point B,  
draw the straight line BG, and so the



others which shall bee lines of de  
fence.  
And to find the Flanke, divide the  
angl

angle EAC in two equal parts by the  
right line HA and the intersection  
which it maketh vpon the line BG at  
the point I shall be the Flanke, then  
take the distance GI, and transport it  
into FK, and so to IG, and the point  
K shall be a Flanke and the point I,  
then draw the line KI, which shall be  
a courtine, and draw the lines KL  
and IM, which shall be the Flank lines  
being drawne perpendicularly to the  
courtine and doing the same to eue-  
ry other side, you shall haue the desi-  
red Fort.

From the point B as center, & from  
the distance AB, let the arke ADC of  
60. degrees be described, and it shall  
be diuided into four equal parts  
whereof AD is one.

From the point D draw the straight  
line DB, which cutting the line AC  
at the point E, doth giue the di-  
stance



## CHAP. VI.

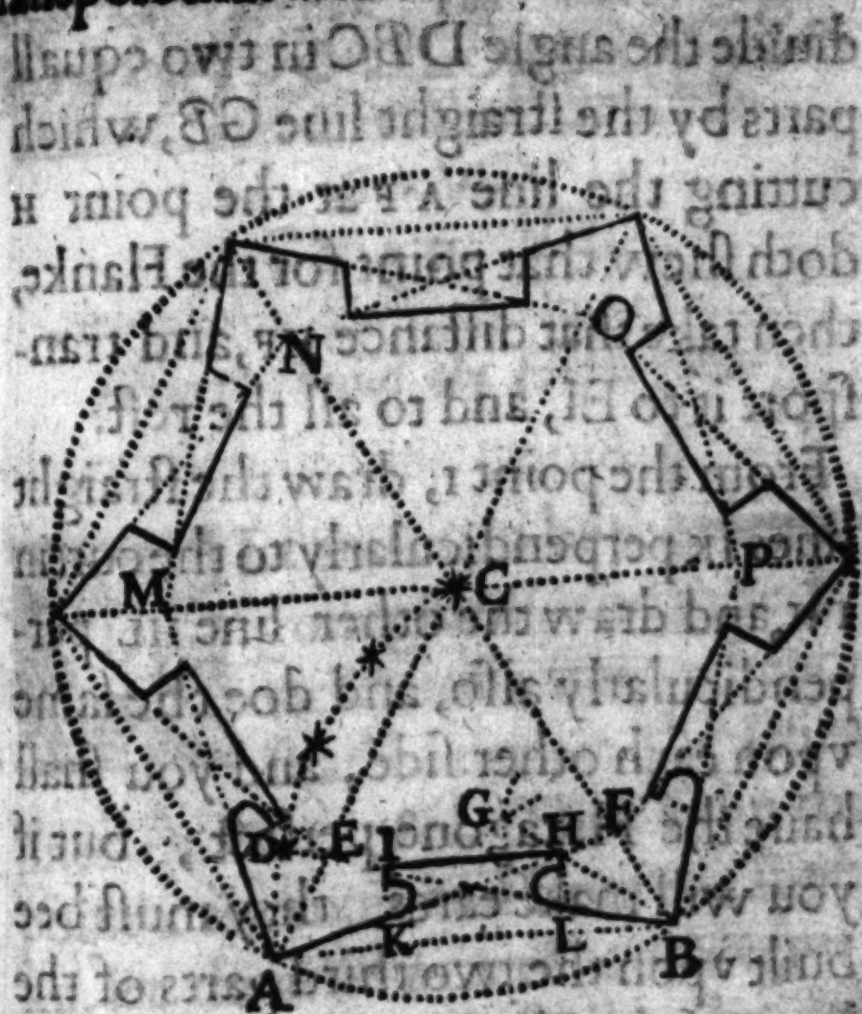
*How to build the Fort Hexagone.*

**H**Aving divided your circle into fixe equall parts, and drawne the fixe straight diagonall lines and the fixe sides.

From the point B as center, & from the distance AB, let the arke ADC of 60. degrees be described, and it shall be divided into foure equall parts, whereof AD is one.

From the point D, draw the straight line DB, which cutting the line AC at the pont E, doth giue the distance

stance AE for the capitall line, then  
transport that distance to BF.



and so round to each angle, & draw  
the straight lines DB AF and the o-  
thers like vnto them which shall be

hereafter the lines of defence. A small

And to find the point for the Flank divide the angle  $DBC$  in two equall parts by the straight line  $GB$ , which cutting the line  $AF$  at the point  $H$  doth shew that point for the Flanke, then take that distance  $HF$ , and transport it to  $EI$ , and to all the rest.

From the point I, draw the straight  
lines IK perpendicularly to the curtain  
IK, and draw the other line HL per-  
pendicularly also, and doe the same  
vpon each other side, and you shall  
haue the Hexagone perfect, but if  
you will make eares, they must bee  
built vpon the two third parts of the  
lines of the Flanke IK HL as appears  
at.

and so round to each angle, & draw  
straight lines DB AF and the o-  
ther like unto them which shall be  
indicated





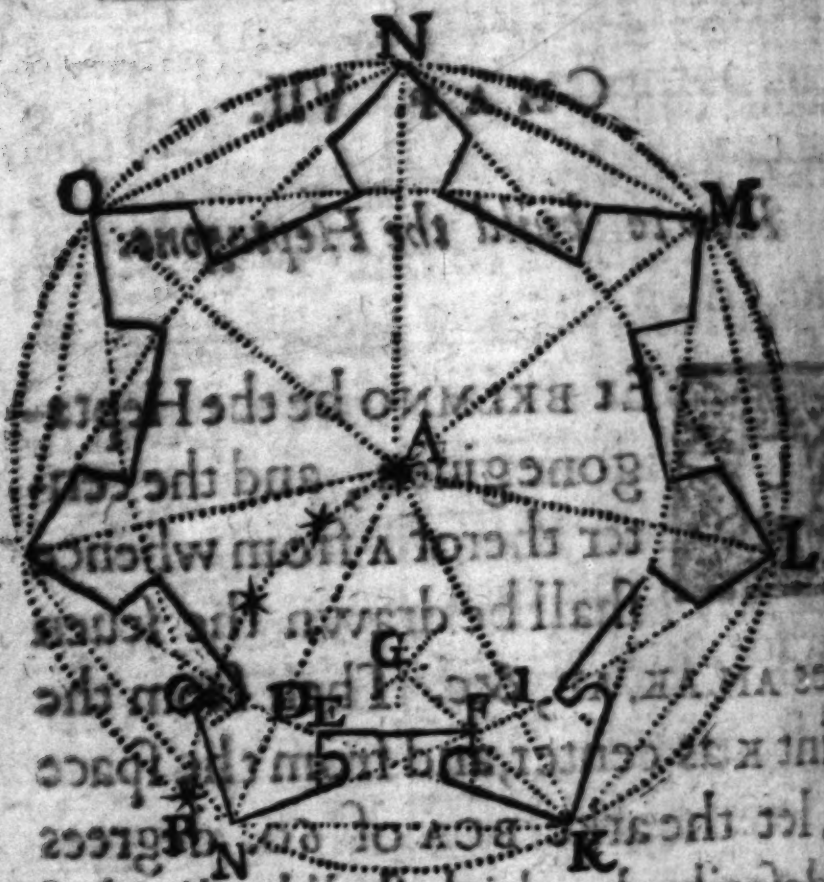
## CHAP. VII.

*How to build the Heptagone.*

Let BKLMNO be the Heptagone giuen, and the center thereof A from whence shall be drawn the seven lines AN. AK. AP, &c. Then from the point K as center, and from the space KB, let the arke BCA of 60. degrees be described, which shall be diuided into foure equal parts, whereof AG shall be one of 15 degrees, from the point C draw the right line CK, the which cutting the line AN at the point

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point D, giueth that part for the capitall line. Then take the distance ND, and carrie it to KI, and to all the



rest likewise, then from the point N draw the right line NI, which shall be the line of defence, and all the others likewise.

And

And to find the point for the flank,  
divide the angle  $AKO$  in two equal  
parts by the right line  $GK$ , which  
cutting the right line  $NI$  at the point  
 $F$  sheweth that intersection  $F$ , for the  
point of the flanke take the distance  
and carry it to  $D$  and  $E$ , and the point  
 $E$  shall be another Flanke, then draw  
from  $E$  to  $F$  the line  $EF$  (which makes  
the courtine) then the two perpen-  
dicular lines for the Flanke lines:  
whereupon shall be built the ears,  
and doing the same vpon each side  
your fort shall be perfect, as required.  
line  $DI$  and the intersection  $K$  shew-  
eth the point for the Flanke, as in  
the Forts preceding, and so transport  
the same side as in the other, and you  
shall have the Fort finished.



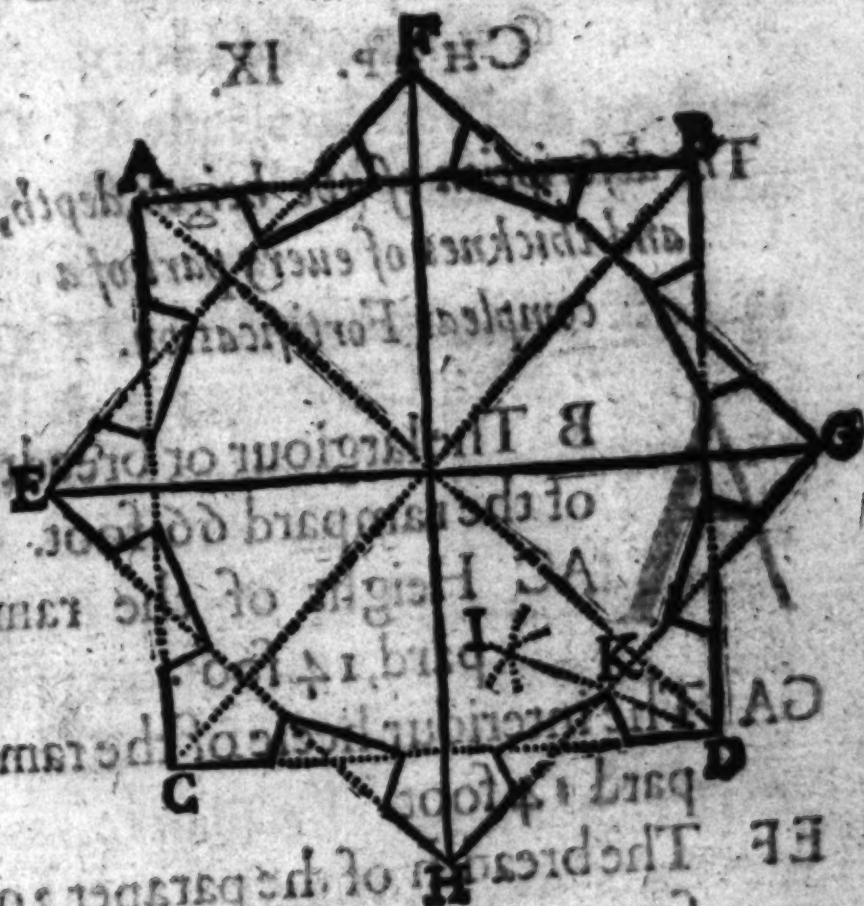
And to find the point for the Flanke  
draw the right line *NI* at the point

Flankewest **CHAP. VIII.**  
point of the Flanke take the distance  
and **How to build the Octogone.**

I shall be another Flanke then draw

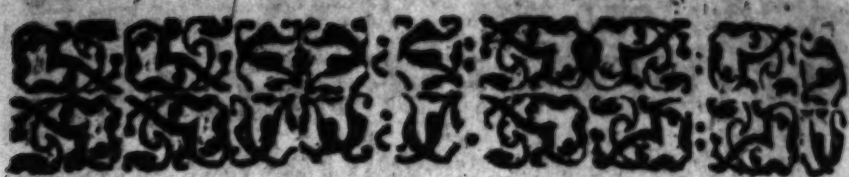
 First let the square *AB*  
be made, & then  
the square *EFGH*.  
And to finde the  
place for the Flanke,  
divide the angle *ADC* by the straight  
line *DI*, and the intersection *K* shew-  
eth the point for the Flanke, as in  
the Forts precedent, and so transport  
to every side as in the other, and you  
shall have the Fort finished.

CH. P. IX.



EF. The breadth of the parapet 20.  
feet.  
EH. Height of the parapet 6 feet.  
BI. The exterior heels of the para.

per 7 feet.  
The covered walke under the  
false Bray 20 feet.  
KL



## CHAP. IX.

*The description of the heighth, depth,  
and thicknes of euery part of a  
compleat Fortification.*



- A** B The largiour or breadth  
of the rampard 66. foot.  
**AC** Height of the ram-  
pard, 14. foot.  
**GA** The interiour heele of the ram-  
pard 14. foot.  
**EF** The breadth of the parapet 20.  
foot.  
**EH** Height of the parapet 6. foot.  
**BI** The exterior heele of the para-  
pet 7. foot.  
**IK** The couered walke vnder the  
false bray 20 foot. **KL**



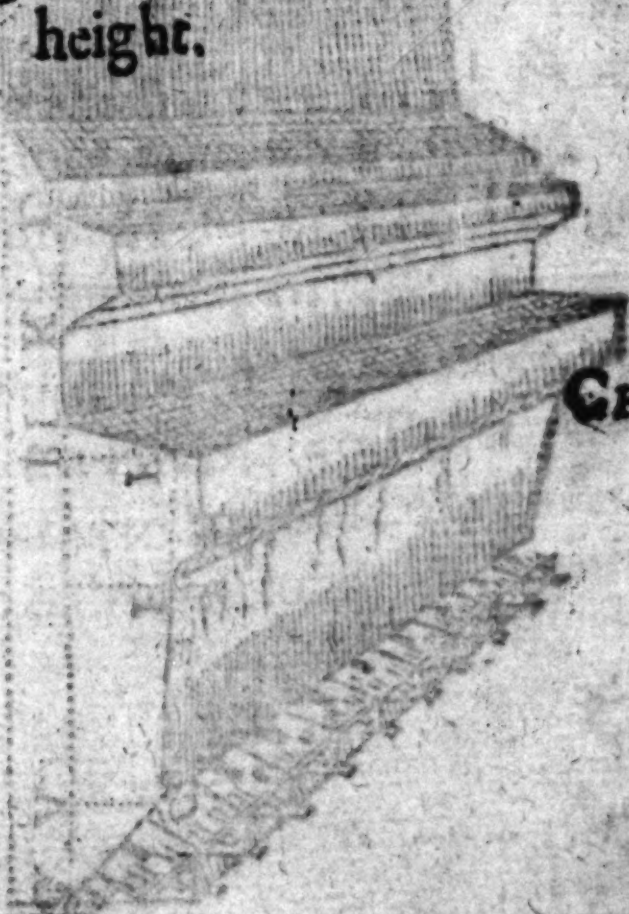
KL The parapet of the false bray  
20 foot.

MN The breadth of the ditch 120  
foot, & the depth thereof ought  
to be 10 foot.

NO The heele of the ditch 10 foot.

OP The covered walk of the counter  
escarpe.

PQ The counter escarpe 6. foot of  
height.



CHAP.

A Treatise of Fortifications. 107  
 KL The top of the false Bray  
 MN The top of the ditch 120  
 NO The height of the ditch 10 foot.  
 OP The height of the wall of the count  
 PQ The height of the wall 6 foot of



CHAP.



# CHAP. X.

*The manner how to fortifie places  
irregularly.*

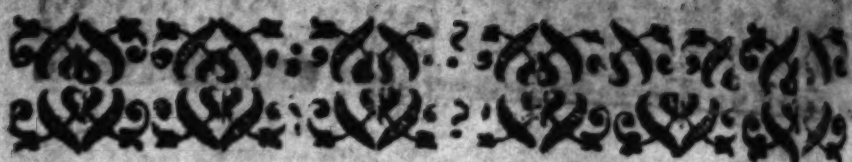


Vpon a line of 100. fathoms is to be made a tenayle; vpon a line of 150. fathoms two half bastions. Vpon a line of 200. fathoms a double tenayle. Vpon a line of 250. fathoms or thereabout is to be made one bastion, and two halfe bastions.

P

CHAP.

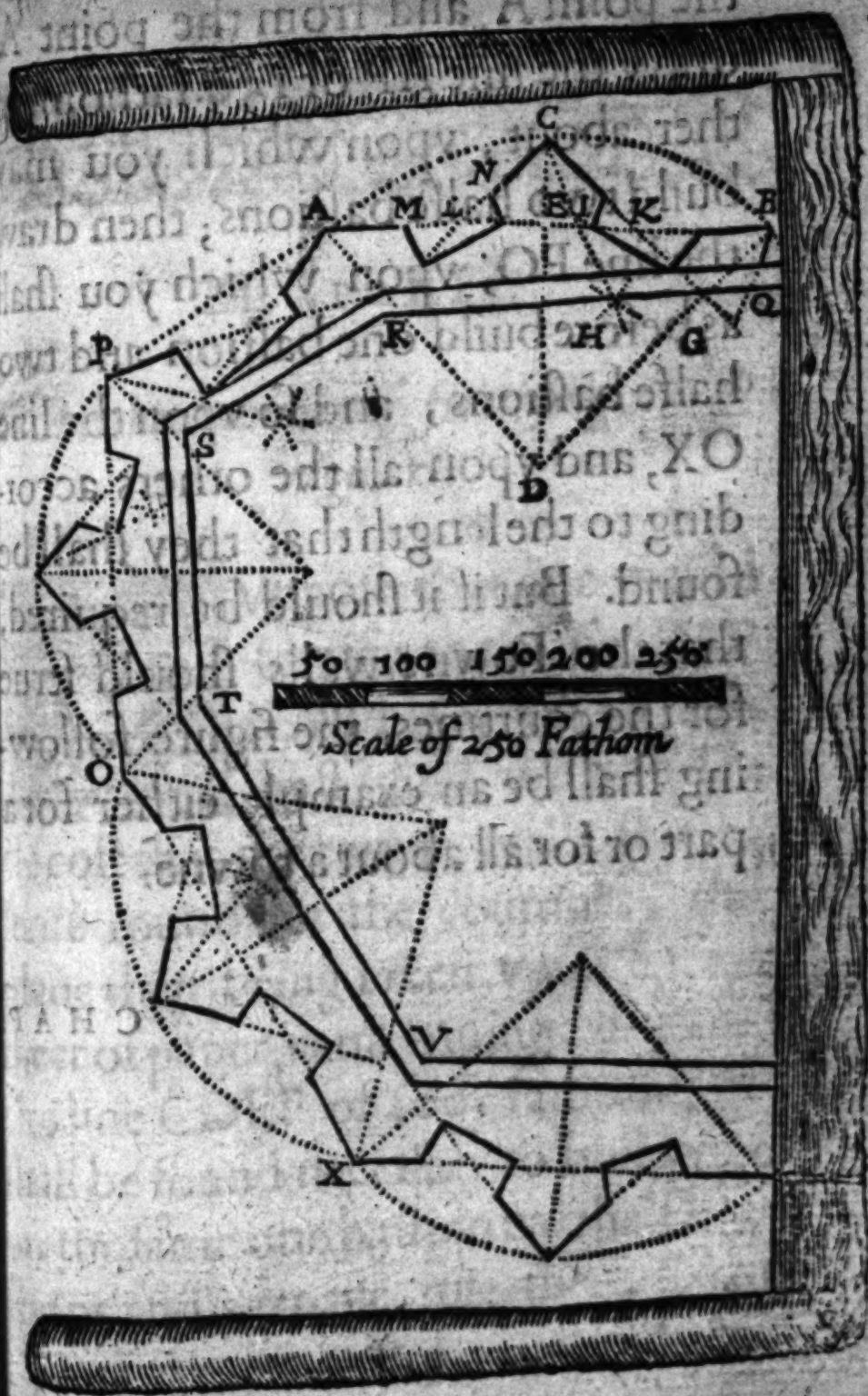




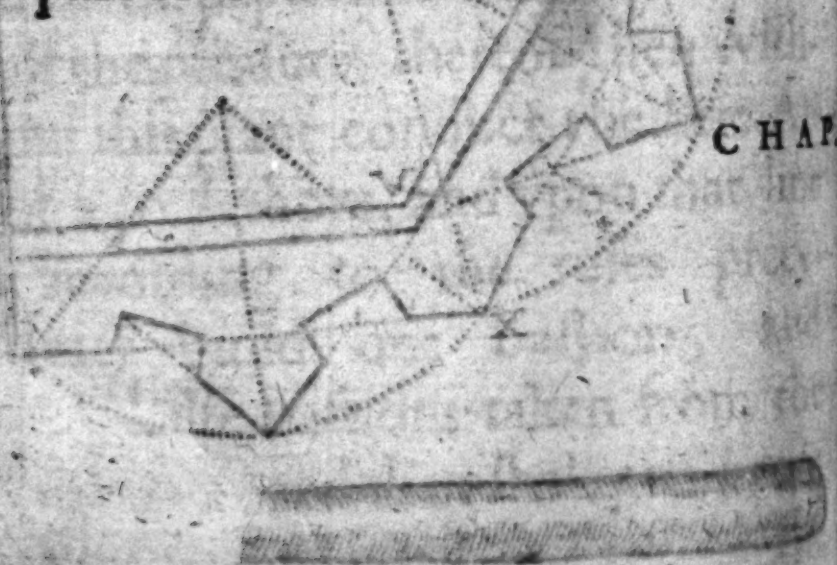
## CHAP. XI.

*A Fortification irregular.*

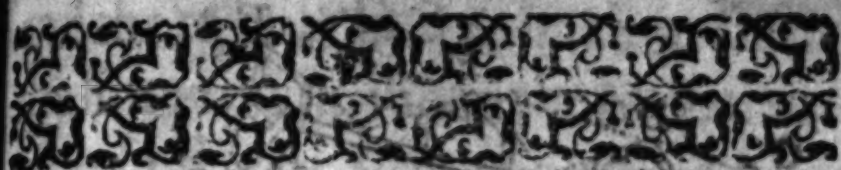
Vppose the place QR  
STV to bee fortified  
without diminishing  
the place, and having  
taken it vpon a faire  
sheet of paper and well considered,  
all the measures thereof then with-  
out this plane conduct the line AB  
of 250. fathom, and vpon that line  
(according to the rules prece-  
dent) build one bastion, and  
two halfe bastions taken from the  
Octogon, and then shall you bee at  
the



the point A, and from the point A, draw the line AP of 150. fathom, or thereabout, vpon which you may build two halfe bastions; then draw the line PO, vpon which you shall as before build one bastion and two halfe bastions, and so vpon the line OX, and vpon all the others according to the length that they shall be found. But if it should be required, that the Towne-walls should serue for the courtines, the figure following shall be an example either for a part or for all about a towne.







CHAP. XII.

*Another manner of fortifying irregularly.*



Vppose that one would fortifie the plane BAP LMNO, but in such hast, and with so little cost that the towne walls should serue round for the courtines, the plane then being taken vpon a faire sheet of paper, and hauing drawne the line CDEF of 400. fathom, it shall be found necessary to build vpon the same one bastion two half bastions and a tenaile, viz. the bastion

P 3

E,



E, the two halfe bastions D and F, and the tenaile DC, & hauing drawn the lines round about the town, leauing sufficient space betwene them and the walls to build bulwarkes or bastions, you may take for the length of euery line of defence, that is to say from the flanke of one bastion to the point of another, 100. or 110 fathom and so euery bastion shall bee scowred with musket shot, as the forts built regularly. This may serue for an example to those who by chance, may haue occasiō to repair or strengthen any part of a towne, wall, or the whole, and for the fortifying of the wall, the earth must be raised in the inside as a rampard.





A TREATISE OF ARITHMETIKE.

CHAP. I.

*Addition*

**S**Ince that Arithmetike is absolutely necessary, and required in diuers and many Geometrical operations, I haue added the examples following onely to renew and refresh the memorie of those who haue alreadie studied it, and not those who are quite ignorant therein, (commending them to large and ample Treatises together with masters of the science) but for such as by a weake memory haue let slip the habi-

habitude which by practise they had in times past obtained, who may easily recover by this short Treatie sufficient knowledge to performe any ordinary operation beginning with Addition, which is a collection of many numbers in one, as hee who would add together the numbers ABC, following to haue the summe D, must begin with the first colon:

6 4 1. A

3 5. B

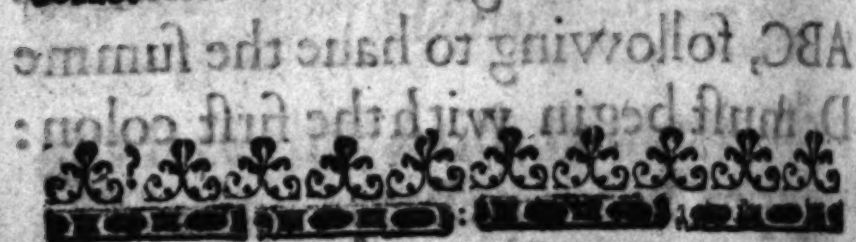
2. C

---

8. D

And say 2 and 5, or 7 and 1 is 8, and set 8 vnder the line, as appears by the example above, then in the second colon say 3 and 4 or 7, and pose them as before; afterward say for the

the 3. colon 6. are fixe, & posing or setting the numbers collected directly vnder the figures not collected as 8 vnder 2, and 7 vnder 3, and fixe vnder fixe, but if any should be above the number of 9, then to set 0 in the place, and set forward all the tens.



### *The Proofs.*

**M**ay be made in casting all the 9 away, though many times, fals but by subtraction is the way most certaine, as thus, begin with the last collon and say 6, cut of 6, rest nothing, and giue the 6 vnder the line a slash, then 4 and 3, or 7 and 7, out of



of 7 rest nothing, and as before giue it a slash, then 1, 5 and 2, or 8, which as before shall be made nothing, the synderneath.

C. 1 5 4

107



CHAP. II.

*Substraction.*

**S**ubstraction is to take away a little number from, or out of a greater, as if one would from 8642 take away 431, then must the numbers bee disposed as followeth, the greater number vppermost, and the lesser vndermost, then draw a line:

Great

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Great number 8642. A  
 Lesser number 4321. B  
 rest 4321. C

And say he that of 2 in the rank pay-  
 eth one, rests 1, the which set vnder  
 the line, then of 4 pay 2, rests 2,  
 which must also bee set vnder the  
 line, and who payes 3 out of 6. rests  
 3. setting them as before, then 4.  
 out of 8 rests 4. which shall bee also  
 set as the others in the example a-  
 boue.

The  
 draw a line:  
 Great



The Proofo.

IS made in adding the lesser number B with the rest C as followeth.

|                |      |
|----------------|------|
| Little number. | 4321 |
| rest           | 4321 |
| Great number.  | 8642 |

And the sum shall be the first number A, if the subtraction haue beene well made. †

As if one would multiply 6 by 3, that is to say as often as 3 contains 6, by 3. CHAP.





## CHAP. III

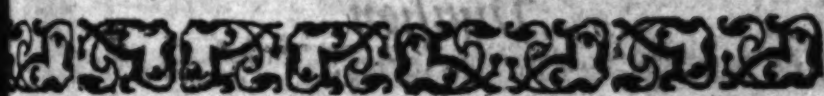
*Multiplication.*

Multiplication is the assumption of one number, as many times as the other, containeth in it selfe vnities.

$$\begin{array}{r} 652 \\ \times 4 \\ \hline 2608 \end{array}$$

As if one would multiply 6. by 3, that is, to take as oft 6 as 3 containes vnities, as in the example aboue, where

where 2 taken 4 times makes 8, and  
5 taken 4 times makes 20. so that  
the number A multiplied by the nū-  
ber B multiplicator 4 times compre-  
hended, make the product 2608.



*The Proofs.*

IS made onely diuiding the pro-  
duct 2608 by the multiplication 4  
and the quotient will be 652. if the  
multiplication were well made, as  
appeares in the example following.

$$\begin{array}{r} 2608(652 \\ 442 \end{array}$$

CHAP.

## CHAP. IV.

*Diuision.*

**D**Iuision is the separation of a number into aliquot partes thereof, as to diuide 5689 by 25. the figures must be disposed, as followeth, viz. the diuisor vnder the first figures of the number, which is to be diuided, as for example.

5689 6

25

And after the last figure of the number, shall bee drawne a halfe circle to separate the quotient. The numbers



numbers being thus disposed, then say  
2 in 5 how many times, and it shall  
be found twice; then set 2 behind  
the halfe circle as in the first example  
following; and then say twice 2 are  
4 of 5 rests 1, dashing out the 2 and  
the 5. and let the 1 over 5, and say a-  
gaine twice 5 are 10. and strike out  
the 5 diuisor vnder the 6. and also  
the 1. over the 5, then set forward  
your diuisor one figure more as in the  
second example, and say 2 in 6. how  
how many times, and it shall be found  
2, and say twice 2 are 4, and 4 out of  
6. rests 2. which shall be set over the  
6, then say twice 5 are 10. and 10. out  
of 18. rests 8 and 1 out of 2. rests 1.  
then dash out the 2. and let 1. over  
it; and also dash out the 5 and 2. di-  
uisors, and set more forward the di-  
uisors, as in the third example, and  
say

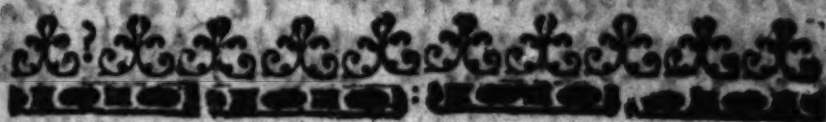
2

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say 2 how many times 18. and it shall be found 7. times, and having set the 7, say 7 times 2 is 14. and 14 out of 18 rests 4, and set the 4 over the 8; and to conclude, say 7 times 5 are 35, and 35 out of 39 rests 4, and 3 out of 4 rests 1, and so your division is ended, as appeares here following by three examples one of each operation.

| I      |         | XI       |    |
|--------|---------|----------|----|
| X      | XII     | XIIII    | 14 |
| 5689(2 | 5689(22 | 5689(227 | 14 |
| 255    | 255     | 2555     | 14 |
|        | 2       | 22       |    |

The



*The Proove.*

**M**ultiplie the quotient 227. by the diuisor 25, and to the product partiall, adde the numbers which rest, *viz.* 14. if any rest, and then adde the whole together, and the product shall be the first number if the diuision hath beene well made as in the example following.

$$\begin{array}{r}
 227 \\
 25 \\
 \hline
 1135 \\
 454 \\
 14 \\
 \hline
 5689
 \end{array}$$

Q 2

CHAP.





## CHAP. V.

### Rules of Fractions.



A Fraction is a number noting the *partes aliquot* of an entire or whole number, whereof it is said to be a fraction as a penny, the twelfth part of a shilling, one inch the fourth and fortieth part of an Ell, &c.

CHAP.



CHAP. V. I.

*How to reduce intiers and Fractions all into Fractions.*

**T**O reduce  $8\frac{3}{4}$  and  $5\frac{1}{2}$  all in fractions you must multiplye 8 by 4, saying 4. times 8 is 32, and the 3 being added, makes 35, which shall be set aboue a line iust vnder the first figures, and vnder that line set 4, as in the example following, to shew that the 45 are al fourth parts, and doe in the like manner by the  $5\frac{1}{2}$ , and say 3 times 5 are 15, and 2 makes 17. and so you shall haue 17. thirds, as in the example following.

23

To

To reduce  $8\frac{3}{4}$  and  $5\frac{2}{3}$  all into fractions.

$8\frac{3}{4}$   $5\frac{2}{3}$

4 3



# CHAP. VI.

To reduce all fractions into one denomination.

**T**O bring these two fractions to one deno. the 35 quarters numerators must bee multiplied by the other numerators 17 thirds, and set the product over as lines here following, then multiply the 4 denominator by the other 3 deno.



denominator, and set the product of those vnder the line, and then will there be,

585



*Addition of Fractions.*

**T**O adde  $\frac{2}{3}$  to  $\frac{1}{4}$  the figures, dispose the figures as followeth, and say 3 times 1 is 3, and set the 3. ouer a line aboue the head of the others, and then say 4 times 2 are 8. and set them ouer a line aboue the head of the others also, then say 3 and

24

8

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8 are 11, and set them over a line between the first numbers and the 11, shall be numerators, and say 4 times 3 are 12, & set them vnder the middle line, and those shall be denominators, and so you shall haue eleuen twelfth parts as followeth.

$$\begin{array}{r} 8 \qquad 3 \\ \hline 2 \quad 11 \quad 1 \\ \hline 3 \quad 12 \quad 4 \end{array}$$

But if the numerator be greater then the denominator, then it shall be divided by the denominator, and the product shall be an entire or entires, and what resteth (if any rest) shall be fraction, which ought to be abridged, as appeareth here following.

8

18

$$\frac{18}{\underline{\quad}}$$

$$\frac{20}{\underline{\quad}}$$

$$\frac{3}{4} \text{ IV } \frac{38}{24} \text{ A } \frac{5}{6} \text{ C}$$

Where the numerator 38 is greater  
then the denominator 24. then be-  
ing divided by the denominator 24.  
doth yeeld 1 intire, and  $\frac{14}{24}$  the which  
being abridged come to  $\frac{7}{12}$ , which is  
almost two thirds, and so of all o-  
thers.

in the precedent chapter, and the  
product as appears following.

$$\frac{3}{8}$$

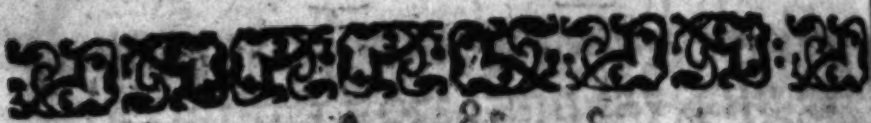
CHAP.

$$\frac{1}{11} \quad \frac{11}{12} \quad \frac{3}{12}$$

$$\frac{1}{12} \quad \frac{11}{12} \quad \frac{3}{12}$$

CHAP.





CHAP. VII.

*Additions of intiers and fractions*

**B**eing proposed to 243<sup>1</sup>/<sub>2</sub> vnto 462<sup>1</sup>/<sub>4</sub>, the intiers must be added as in the first chapter of Addition and the fractions must be added as in the precedent chapter, and let product as appears following.

|               |                |               |
|---------------|----------------|---------------|
| $\frac{8}{-}$ |                | $\frac{3}{-}$ |
| $\frac{2}{-}$ | $\frac{11}{-}$ | $\frac{1}{-}$ |
| 3             | 12             | 4             |

CHAP.

twene both, and afterward  
~~the~~  
~~the~~  
~~the~~

them under the middle line, which  
 shall bee the denominators for the  
 rest, as appears clearly in the ex-  
 ample following.

### Substraction of Fractions.

Out of 9 pay 8



Whoever would sub-  
 tract  $\frac{2}{3}$  from  $\frac{3}{4}$  must dis-  
 pose the figures, as in  
 the example following;

and first multiply the numerators  
 by the denominators a crosse, as 3  
 times 4 are 12. and 4 times 2 are 8,  
 and set 12 and 8 over the lines above  
 the heads of the others, and then  
 say take 8 out of 12, and there rests 4,  
 which must bee set over a line be-  
 twene

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tweene both, and afterward say 3 times 4 is 12, multiplying denominators by denominators, and set them vnder the middle line, which shall bee the denominators for the rest, as appeares cleerely in the example following.

Out of 9 pay 8 rest 1

the example following:  
 and first multiply the numerators by the denominators a crosse, as 3 times 2 are 6, and 4 times 2 are 8, and set 9 and 8 over the lines above the heads of the others, and then say take 8 out of 9, and there rests 1, which must be set over a line between

CHAP.



## CHAP. IX.

Rests

*Subtractions of intiers and fractions.*

**T**O subtract  $18\frac{3}{4}$  from  $26\frac{7}{8}$ ; the fractions must first be multiplied as in the example following; and say twice 2 are 4, and set the 4 ouer a line, then 3 times 1 are 3, and set them ouer a line, and then who payes 3 out of 4. rests 1, which must be set ouer the middle line, which done, multiply the one denominator by the other, and set the product vnder that which doth rest, as followeth.

Receiued

|          |                  |  |               |               |               |
|----------|------------------|--|---------------|---------------|---------------|
| Receiued | $267\frac{2}{3}$ |  | $\frac{4}{-}$ |               | $\frac{3}{-}$ |
|          | $183\frac{1}{2}$ |  | $\frac{2}{-}$ | $\frac{1}{-}$ | $\frac{1}{-}$ |
| Rests    | $84\frac{1}{2}$  |  | 3             | 6             | 2             |

But if the fraction of the receiued should be lesse then the fraction of the summe paid, then must there be one borrowed from the whole or intire number, and count it according to the denomination of the fraction: for if the denominator bee 4, then shall the intier be  $\frac{4}{4}$ , if 5, then  $\frac{5}{5}$ , if 6 then  $\frac{6}{6}$  &c.

CHAP.  
which must be set over the middle  
which done, multiply the one  
denominator by the other, and set  
the product under that which doth  
follow.

Receiued



## CHAP. X.

### *Multiplication of Fractions.*

**L**Et there bee proposed a superficies in the forme of a parallelogram, vulgarly cald square, the sides whereof the one is in length  $\frac{7}{8}$  of a fathom, and the other in breadth  $\frac{3}{4}$  and these two fractions are to bee multiplied together to find out how much the whole superficies doth containe the figures must be disposed as followeth.

$$\begin{array}{r} \frac{7}{8} \\ 3 \overline{) 4 \frac{21}{32}} \end{array}$$

multiply

$$\frac{7}{8} \quad \frac{21}{32} \quad \frac{3}{4}$$

And



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And multiplie one numerator by the other numerator, and then one denominator by the other denominator, saying 3 times seven is 21, and set them ouer head, then foure times 8 is 32, and set them vnderneath, and the whole will bee  $\frac{21}{32}$  parts of a fathom, which certainly containeth the required superficies.

CHAP.

$$\frac{3}{4} \times \frac{7}{8} = \frac{21}{32}$$

$$\frac{3}{4} \times \frac{7}{8} = \frac{21}{32}$$

And

## CHAP. XI.

*Multiplication of entiers and Fractions.*

**T**O multiply  $2\frac{1}{4}$  by  $2\frac{1}{2}$ , you must first of all reduce the whole into fractions, and then as here about multiply numerator by numerator, and denominator by denominator, and the product will bee  $4\frac{5}{8}$ , as plainly appears by the example following.

$$2\frac{1}{4}$$

by

$$2\frac{1}{2}$$

$$\frac{9}{4}$$

$$\frac{4\frac{1}{2}}{8}$$

$$\frac{5}{2}$$

R

But

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But if it were proposed to multiply greater numbers, as 20 by  $15\frac{26}{29}$ , then multiply the 15. intiers by the deno. 29. of the fraction, & then adde the numerator 26 of the same fraction; which done will mount to  $461\frac{26}{29}$ , then set the 461 ouer a line, and the 29. vnder it, and afterward multiply the 20 intiers by the 461. which done, diuide the product of the whole by the denominator 29. and the number required shall bee  $317\frac{27}{29}$ , as appears:

$$\begin{array}{r}
 20 \text{ by } 15\frac{26}{29} \\
 \hline
 20 \quad 461 \\
 \hline
 9220
 \end{array}
 \qquad
 \begin{array}{r}
 461 \\
 20 \\
 \hline
 9220
 \end{array}
 \qquad
 \begin{array}{r}
 22 \\
 29 \\
 \hline
 3537 \\
 9220 \\
 \hline
 2998 \\
 221
 \end{array}
 \qquad
 \begin{array}{r}
 20 \\
 1 \\
 \hline
 1
 \end{array}
 \qquad
 \begin{array}{r}
 461 \\
 29 \\
 \hline
 29
 \end{array}
 \qquad
 \begin{array}{r}
 317\frac{27}{29}
 \end{array}$$

CHAP.





## CHAP. XII.

### *The diuision of Fractions.*

**T**O diuide  $\frac{3}{4}$  by  $\frac{4}{5}$ , each numerator is to bee multiplied by each denominator opposite, and set the product ouer a line aboue them, and then diuide the greatest product by the least as followeth.

$$\begin{array}{r}
 2 \quad 4 \\
 3 \quad 5 \\
 \hline
 15 \quad 20 \\
 12 \quad 15 \\
 \hline
 15 \quad 20
 \end{array}$$

R 2

CHAP.



## CHAP. XIII.

*To diuide intiers and fractions by  
intiers and fractions.*

**T**O diuide  $12\frac{2}{3}$  by  $3\frac{1}{6}$ , they must first be reduced all into fractions as before, and then you must multiply the numerators by the denominators acrosse as followeth, and then diuide the greatest product by the least, as this example doth cleerely demonstrate.

$$\frac{228}{57}$$

$$\frac{57}{31}$$

diuision

$$228(4$$

$$57$$

$$\frac{31}{6}$$

$$\frac{19}{6}$$

CHAP.



## C H A P. XIV.

*Evaluation of fractions which  
may not be abridged.*

**S** Vppose you were to abridge: 7 parts of a fathom, first you must consider what are the parts of the intier or whole, as 6. foot, or 72. inches: then you must multiply the numerator 7, by the denominator 72 parts, and let the product bee divided by the denominator 9, and then you will finde 56 inches for the eualuation of  $\frac{7}{9}$  parts of a fathom.

R 3

72



72

7

504

diuision

5

504(56

99

By this meanes any fraction may be abridged as well in Geometric as as commerce, although they seeme not to be abridged.



# CHAP. XV.

*For the eualuation of measuring  
lands.*

**Y**OU must consider that the fathom of 6 foot in length, doth containe in superficies 36. and that  
the

## *A Treatise of Arithmetike.*

the 72 inches in length doth contain  
in superficies 5184 inches, and of o-  
ther measures then to valuate a fra-  
ction of  $\frac{19}{47}$  parts of a fathom, square  
in superficies you must multiply  
5184 by 19. and diuide the product  
by 47, and there will be 2095 inches  
for the square of  $\frac{19}{47}$  of a fathom square  
and so of other like measures.



**R 4**

**CHAP.**



## CHAP. XVI.

*Of the rule of three without fractions.*



Multiply the second number 400 by the third 12. and product 4800 by the first number 4, and the quotient shall be the number required, and dispose your rule, as followeth.

months.---pounds.--months.

If in 4---400-----12

The





*The probation of this  
Rule.*

**I**S to multtple the first num-  
ber 4 by the fourth number  
1200, and to multipliethe second  
by the third, and the two products  
will bee equall if the rule bee well  
made.

**CHAP.**

Which done, you must multiply the  
second number of fractions as by  
the



## CHAP. XVII.

*Of the rule of three with intiers  
and fractions.*

**F**irst all the intiers must bee reduced into fractions as followeth.

yards                      pounds                      yards  
If  $2\frac{1}{4}$  —————  $12\frac{1}{2}$  —————  $7\frac{1}{2}$

CHAP.  $\frac{9}{4}$                        $\frac{25}{2}$                        $\frac{15}{2}$

Which done, you must multiply the second number of fractions as by the

the third number of fractions 15, & then againe multiply the product by the denominator of the first number, and then say 2 times 2, or 4, and 4 times 9 is 36, which must bee set under the line, by which you shal divide the first product 1500, and the quotient shall bee the number required, as appeares,

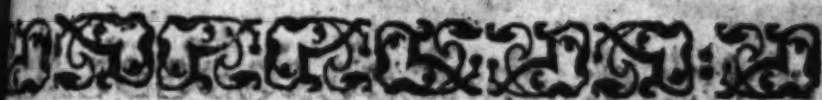
|           |                            |
|-----------|----------------------------|
| 25        |                            |
| <u>15</u> | 3                          |
| 125       | 3                          |
| <u>25</u> | 364                        |
| 375       | 1500 (41 $\frac{14}{16}$ ) |
| <u>4</u>  | 360                        |
| 1500      | 3                          |

Heere followeth two examples, differing the one from the other; whereof the manner of multiplying the one, is more easier then the other the first is multiplyed as the precedent, but the last is multiplied first by



by all the intirres, viz. by 3, by 8  
 and by three, leauing the fraction  
 by it selfe, and after all take the third  
 of the intier, viz. of 50000, saying the  
 third part of 5 is one rest 2, for the  
 0 which is valuated at 20, then say  
 the third part of 20 is 6, and so rests  
 2 for the second 0, and so to the end  
 and what shall rest at last, shall be set  
 ouer a line, and your 3 4th or 5  
 vnder the line, then all being added  
 together, you shal diuide the product  
 cutting off the figures to the quanti-  
 tie of the first number, saying, by ten,  
 by a hundred, by a thousand, by ten  
 thousand, by a hundred thousand, &  
 the remainder is the number requi-  
 red, as appeareth, 191 $\frac{2}{3}$ .

The



*The first example.*

If  $100000 \rightarrow 383\frac{1}{3} \rightarrow 50000$ .

100000 --- 1150 --- 50000 ---  
I --- 3 --- I

The second number being multiplied by the third, doth mount to 7500000, and being diuided by the first multiplied by 3, as before is taught, the quotient will be  $191\frac{2}{7}$ .

**The**



*The second example.*

IF 100000—383 $\frac{1}{2}$ —50000

383 $\frac{1}{2}$

150000

400000

150000

166 66 $\frac{2}{3}$

191, 6, 6, 6, 6, 6 $\frac{2}{3}$





## CHAP. XVIII.

### *Extraction of the square roote.*

**F**irst dispose your numbers as followeth out of which you meane to draw the roote separating your figures by two and two beginning at the latter end; but first strike the halfe circle 73|21|01 (and then say the root of 73 is 8, and set 8 before the half circle, & rests 9, then double the quotient 8, and say 2 times 8 are 16, and set the 6 vnder the last figure of the second part of figures, and 1 vnder

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der the first figure of the first part as  
In this first example.

$$\begin{array}{r} 9 \\ 75 \overline{) 2101} (8 \\ \underline{600} \phantom{0} \\ 501 \phantom{0} \\ \underline{400} \phantom{0} \\ 101 \phantom{0} \\ \underline{80} \phantom{0} \\ 21 \phantom{0} \\ \underline{16} \phantom{0} \\ 5 \phantom{0} \end{array}$$

Then say how many times is 1 in 9,  
and it shall be 5. which you shall al-  
so set vnder the 1 of the second sepa-  
ration, as appears in this second  
example.

$$\begin{array}{r} 9 \phantom{0} 96 \\ 78 \overline{) 2101} (85 \\ \underline{63} \phantom{0} \\ 47 \phantom{0} \\ \underline{38} \phantom{0} \\ 9 \phantom{0} \\ \underline{72} \phantom{0} \\ 18 \phantom{0} \\ \underline{15} \phantom{0} \\ 3 \phantom{0} \end{array}$$

And then say 5 times 1 are 5, which  
taken out of 9 rests 4, and 5 times 6  
are 30, and 30 out of 32 rests 2, and  
13 out of 4 rest 1, and then againe say  
5 times 5 are 25, which out of 31

rest 6. and 3. out of 12. rest 9. and then double the quotient, and say twice 3 are 6 set 0 vnder 0 of the last separation, and keepe 1 in memorie, and say twice 8 are 16, and 1 that I keepe in mind makes 17, then set downe 7 vnder the 5, and the 1 vnder the 6 of the middle separation, as appears in this example following.

$$\begin{array}{r}
 x \\
 * \\
 996 \\
 72 \overline{) 2101} \text{ (85} \\
 x \overline{) 6510} \\
 17
 \end{array}$$

And then say how many times is 1 in 9 and it shall be 5 times, which shall be set downe for quotient, and also vnder the last figure 1, and then say 5 times 1 are 5, out of 9 rests 4, and 5 times 7 are 35, which out of

S

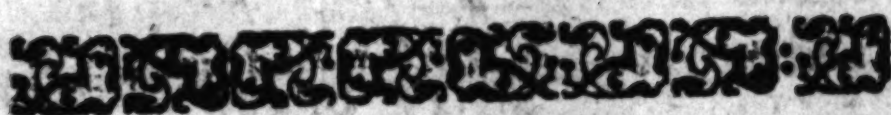
36



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36 rests 1, and 3 out of 4 rests 1, and 5 times 0 is 0, and 5 times 5 are 25. out of 31 rests 6, & 3 out of 10 rests 7, and 1 out of 1 rests 0, and so the rule is ended as appeares following.

$$\begin{array}{r}
 x \ 1 \ 0 \\
 * * * \\
 6 \ 6 \ 6 \ 7 \ 6 \\
 7 \ 3 \ 2 \ 1 \ 0 \ 1 \ (8 \ 5 \ 5 \\
 x \ 0 \ 5 \ 0 \ 5 \\
 x \ 7
 \end{array}$$



## CHAP. XIX.

*Another example of the square root.*

$$\begin{array}{r}
 2 \\
 2 \quad 7 \ 8 \\
 6 \quad | \ 3 \ 2 \ 6 \ 9 \ (2 \ 5 \ 1 \ \frac{11}{101} \\
 \quad | \ 4 \ 8 \ | \ 0 \ 1 \\
 \quad \quad 5
 \end{array}$$

After you haue separated your figures

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gures by two and two, and drawne  
251 the square roote, there doth yet  
rest 268, which must bee reduced in-  
to fractions, and to begin set that rest  
268 ouer a line at the end of your  
root, and that rest shall be numerator  
of the fraction; and to finde the de-  
nominator only, double the root 251  
if it be bigger then the rest, but if  
less as here, adde one to the doubling  
of the first figure, saying twice 1 is 2,  
and 1 that I adde makes 3, adde only  
double the rest, and set it vnder the  
line, and that shall be the denomina-  
tor of the fraction; and to haue the  
root of this fraction here aboue, first  
take the root of the numerator, and  
set that root ouer a line, and it shall  
be numerator as appeares following.

$$\begin{array}{r}
 1 \\
 2 \overline{) 42} \\
 \underline{26} \phantom{0} \\
 16
 \end{array}$$

Then draw roote of the denomina-  
tor, and set it vnder the line, and that  
shall be a denominator, and so you  
shall finde  $\frac{16}{26}$ , and what rests is vn-  
fible.

$$\begin{array}{r}
 1 \\
 2 \overline{) 29} \\
 \underline{20} \phantom{0} \\
 9
 \end{array}$$

But because that this fraction  $\frac{16}{26}$  is not  
precisely perfect, and that there is a  
rest in each extraction, you may ope-  
rate as followeth to haue it mooue  
exactly, adde as well to the numera-  
tor as to the denominator two 00, or  
foure, or sixe, &c, and from each pro-  
duct



duct or quotient out of one figure for every two 00 which you shall haue added, and the more that you adde 00, the more precisely you shall haue the roote as appears following.

$$\begin{array}{r}
 2 \\
 \times 3 \quad 3 \\
 \hline
 1 \quad 4 \quad 2 \quad 4 \quad 1 \\
 2 \quad 0 \quad 8 \quad 0 \quad 0 \quad (16 \quad \frac{11}{17} \\
 \hline
 1 \quad 2 \quad 0 \quad 2 \quad 2 \\
 3
 \end{array}$$

But if it were proposed to extract the square roote of  $\frac{16}{37}$ , there would nothing rest, nor would it bee needfull to adde any 00, for the roote of 16 is 4, and the roote of 25 is 5, and so wee should haue  $\frac{4}{5}$ , and the like in all such other accidents; and thus much for Arithmetike. *Vale.*

FINIS.

fact of nature and the nature for  
that two or three or four have  
added, and the result you add  
to the more precisely you shall have  
the more accurate following

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but if it were proposed to extract the  
square root of 8, that would not  
bring off, nor would a decimal  
to a like any as for the root of 10 is 4  
and the root of 2 is 1.414, and so we  
should have, and the like in all such  
other accidents, and thus much for  
Arithmetic.

FINIS.



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